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EDITORIAL

SOIL PROBLEMS

IF a survey of our surface soil could have been made before attempts were made to grow agricultural crops in it a very large amount of energy and expense would have been saved. A recent preliminary survey of this nature in connexion with one of our colonisation schemes has shown at once land that may carry a paddy crop, other situations which certainly will not do so but might produce fruit trees, whilst a third region of open pasture-like land, although possible of irrigation, is plainly indicated as being of little agricultural application.

As land becomes settled the cultivators themselves in the course of time come to know of what nature it is and from experience make adaptations of crops to suit different areas, this however is a slow process and any assistance that can be given in the initial stages of opening up land is often labour and money saved.

The first necessities in Ceylon are a determination of the main soil types to be found in the Island and then a regional survey indicating where these are to be found. These points are especially valuable with us where we have more land than the population can work. In countries of highly intensive agriculture the situation is different for here the soil is primarily regarded as somewhere that the plant can stand the climatic environment whilst the character of the medium in which it grows can be modified to suit its nutrition.

Whilst the climatic environment cannot be altered at will certain of its effects upon the soil can and often must be brought under control in the interest of the population. A most outstanding effect of this kind is soil erosion, so great a problem with us. In certain of the older agricultural countries where a dense population has to be supported on the land a type of soil depletion has been introduced by the cultivators themselves that has reduced the fields to a condition of minimum yield. This has occurred where one variety of crop has for instance been raised from the same land year after year and the crop been exported from the district and that which was taken from the soil been in no way returned to it. Most countries, however, have now realised this phenomenon and taken steps to correct it by introducing a system of rotation of crops or a system of mixed farming.

In Ceylon we have a third form of soil impoverishment in our shifting cultivation or chena system. Some interesting observations on chena cultivation in relation to forest exploitation have recently been made in the "Report on the Management and Exploitation of the Forests of Ceylon". Old chena districts in the course of time become reduced to a condition of minimum yield both by such cropping and the letting in of the adverse factor of soil erosion. The practice too, has an impeding effect upon any progress in the development of rotational dry land cultivation. Its disastrous influences upon forest development are no less great. The excuse for it is that with our comparatively small populousness the climax is a far-off one, although Mr. Champion in the above report is convinced "that this antiquated form of agriculture must give way to more intensive forms".

A policy of thinking for the future both with regard to the character of our soils and the prevention of their deterioration is one worthy of inculcation.

STUDIES ON CEYLON SOILS

II.—GENERAL CHARACTERISTICS OF CEYLON SOILS · SOME TYPICAL SOIL GROUPS OF THE ISLAND AND A TENTATIVE SCHEME OF CLASSIFICATION

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IN the previous paper of this series [1] some account was given of the principles underlying and the methods adopted in modern soil study and classification and their applicability in Ceylon. It was there indicated that the character of any particular soil is governed by one or more of the following factors: its geological origin, its topography and the climatic conditions to which it was subject. The part which each of these factors plays in the characterisation of the soil, and the ultimate result of their combined action, is reflected in the soil profile which is therefore the unit of present day soil study. In this article an attempt will be made to present a connected general account of the more important or wide-spread groups or series of Ceylon soils, based on the study of the soil profile. In these investigations only one or two typical soil profiles of each of the major groups of soils have been examined in detail, the object being more to determine broad distinctions between groups or series, rather than less marked differences between the individual types constituting each group. From the data thus obtained, some tentative classification of local soils is possible and a scheme is therefore suggested to serve as a working hypothesis. This scheme will doubtless have to be modified in the light of more intensive investigation, but as it offers a basis for future work, there would appear to be some justification for its publication. No attempt will be made to define the boundaries of these soil groups as has been done by Schokalsky [2] as this will require an exhaustive survey.

As however a preliminary to any systematic classification of the soils of a country is a knowledge of its geology, climatic conditions and topography, some account of each of these natural

features of Ceylon will be given, more particularly for the benefit of readers who do not possess a first-hand acquaintance with the Island.

TOPOGRAPHY

The pear-shaped Island of Ceylon, with an area of 25,332 square miles, is situated to the south-east of the Peninsula of India, between 5°·55 secs. and 9°·51 secs. north latitude and 70°·42 secs. and 81°·53 secs. east longitude. It is bordered by a coastal plain, very narrow along the southern margin of the Island but much wider on the western and eastern sides. The northern half of the Island is a great plain. From the coast, the land rises by fairly steep ascents to a central 'massif' forming the rugged highlands, culminating in the peak of Pidurutalagala, 8,290 ft. above sea level. This peak rises from a plain, called the third peneplain, 6,000 ft. above sea level. Between this latter and the coastal plain is a second peneplain 1,600 ft. above sea level. There are, it is reckoned, about 150 mountains varying from 3,000 to 7,200 ft. in altitude. Of these, Adam's Peak, 7,360 ft. high is the most famous from a religious and historical point of view. There are 16 rivers or streams most of which have their source in the hill country. Of these, the Mahaweli Ganga, 206 miles in length, is the largest, and the Kelani Ganga, 93 miles long, next in size and importance. The land bordering these rivers is quite fertile with the accumulation of alluvial silt and clay brought down from the hills.

CLIMATE

The climate of Ceylon, for the major part, is tropical. In the low-country the mean temperature is about 80°F. the range of variation being small. At the other extreme is Nuwara Eliya, at an elevation of over 6,000 ft., with an average temperature of 59·2°F. and a mean daily range of about 15°F. The hottest months on the west coast are March to May and on the east coast May to July.

The rainfall conditions vary a great deal over the Island, the annual range of rainfall being from 25 to over 300 inches. The greater part of rain falls during the two monsoons: the north-east from November to January and the south-west from May to September. In the intervening months inter-monsoon rains are prevalent. The south-west of the Island experiences the highest rainfall, varying from 80 to 300 inches per annum,

whilst the dry areas of the north, north-west and south-east have an average annual precipitation of less than 40 inches. The dry regions mainly benefit by the north-east monsoon. The driest months of the year are February and August.

Soil temperatures taken over a limited period at Peradeniya, in the mid-country, range from 74°F to 77·5°F. Temperatures in the low-country will be correspondingly higher and those up-country, lower.

GEOLOGY

The majority of the rocks of the Island are ancient crystalline rocks belonging to the Archean or Pre-Cambrian Age. They form an extension of the great area of crystalline rocks of South India. In the Jaffna Peninsula and the adjacent parts of the north of the Island these Archean rocks are covered by Miocene limestone. A narrow band of sedimentary rocks of Jurassic age occurs along the north-west coast at a place called Tabbowa. There are in addition littoral deposits of sandstone, raised coral reefs, submerged coastal flats, etc. and thick beds of recent alluvium occupying the valleys. These latter form the chief paddy-growing areas. Of importance from the soil standpoint are certain "plateau deposits" [3] belonging to the Pleistocene Age, which overlie the gneisses and older crystalline rocks. They are widely distributed over the low-country and vary in thickness up to 50 feet or more. They consist typically of two strata, the lower a "gravel" of quartz pebbles and iron concretions in a matrix of red clay, and the upper a red earth which is considered by Wayland to be a wind-borne deposit derived from the crystalline rocks. The gravel bed is not always present and it is not uncommon to find the red earth directly overlying the ancient rocks. The brick red colour is liable to be bleached from various causes to various shades of buff. According to this geologist, the red earth consists of sand grains and a finely divided material which is probably a mixture of kaolin or clay and iron oxides, with perhaps some hydrated aluminium oxides. The white sands (the cinnamon soils) of the Wesern Province and the light sandy soils of the North-Western Province are considered by Wayland to be derived directly from the red earth and to indicate swamp conditions in the past. Tennent [8], on the other hand, attributes the sandy deposits of the Batticaloa and Western coasts to the interaction of the sand-laden river waters and the currents skirting either coast.

Wayland [3] describes the geography of the red earth country as follows: "It is essentially low-lying with large domes generally less than 100 feet in altitude above sea level and 2 or 3 miles in length by, perhaps, $1\frac{1}{2}$ in width. From the plain they resemble low ridges, but are best described as "turtle backs". They are covered with red earths, but the flats between them are of varying composition, and are younger than the red earth. The whole supports dense jungle or cultivation. The plateau beds are extremely pervious to water. All the larger red earth grains are composed mainly of quartz".

The ancient crystalline rocks are divided into the following important classes by Adams [4].

(1). The biotite gneisses which form a very large proportion of these rocks.

(2). Rocks of the Charnokite series of South India. These are a series of igneous rocks which range from highly acid hypersthene granites to norites and basic hornblende hypersthenites. They are characterised by a dark grey to black colour and the presence of hypersthene. They display a well marked foliation or banded structure.

(3). The granulites or leptynites. These are fine grained rocks of a white or pale-pink colour having a massive appearance. Garnets are often present in them. The rocks are largely devoid of the more basic minerals. They possess a foliation which is however not marked.

(4). Metamorphic rocks of sedimentary origin.

(a) Limestone. This mainly occurs in two well-defined bands known as the Badulla and Matale bands. The limestones range in composition from pure carbonate of lime to magnesium limestone or dolomite. The maximum width of a single band is a quarter of a mile.

(b) Khondalite or Sillimanite garnet rocks. These occur interbanded with biotite gneisses.

(c) Quartzites. These rocks are often interbedded with limestone.

(5). The Galle series. These are rocks closely related to the biotite gneisses and having some similarity to the Charnokites. They are of very limited extent and are characterised by

the presence of calcium minerals. Coates [4] includes this series with the Charnokites.

No account of the geology of Ceylon will be complete without some reference to the residual deposits of gneisses and other crystalline rocks, *viz.* laterite or *cabook* as it is known locally, and lateritic clays which mantle considerable areas of these rocks. Laterite chiefly occurs on the western coast from Negombo to Matara and for some distance inland where it is used for building purposes. It is a cellular, reddish, ferruginous clayey material, with mottlings of white hydrated aluminium oxides. The transitory state from gneiss to laterite is represented by the more clayey lateritic loams of the hill country. The red and reddish yellow colours of laterite are contributed by the oxides of iron and decomposed ferro-magnesian minerals, while the white or pale-yellowish colours are largely the result of the decomposition products of felspar. For more detailed information on the geology of Ceylon reference may be made to a publication by Adams [4] and a paper in the press by Coates [5].

CLIMATE, GEOLOGY AND TOPOGRAPHY IN RELATION TO LOCAL SOILS

The relative importance of each of the factors, climate, geology and topography in determining the character of the soils of the Island will now be discussed. Climate is undoubtedly the predominant characterising factor with the majority of our soils. The high temperatures and heavy precipitations alternating with periods of dry weather, which are experienced over a large part of the Island, are eminently favourable for chemical weathering and the development of laterite or lateritic soils where the nature of the parent rock material permits. In the process of laterisation the alkaline bases are leached out in combination with a part of the silica as soluble silicates, leaving a residual material considerably richer in the hydrate oxides of aluminium and iron than the original rock. The more advanced is the laterisation process, the higher is the proportion of sesquioxides (alumina and iron oxides) in the soil and more particularly, the clay complex. It is seldom, however, that pure laterite soils or soils derived solely from laterite are found in Ceylon, the great majority of the coloured soils being the lateritic type. This is all to the good, as laterite soils are generally infertile while those of the lateritic type are of fair agricultural value. Under other

conditions, as when the rainfall is deficient, or the drainage impeded, as in paddy soils, or the geological material unsuitable for laterisation as in the case of the Jaffna limestone, the tendency is for the weathering to be of the kaolinitic or ordinary clay type. Under these conditions the proportion of silica to sesquioxides in the clay complex is generally higher than in lateritic soils, the clay largely consisting of hydrated aluminium silicates, and the soils formed are of potentially greater agricultural value than the latter. Geology and topography in these cases play a more important part in soil characterisation than does climate.

Geological structure bears a close relationship to the character of local soils in extensive areas of the low-country, where the plateau gravels and red earth overlie the crystalline rocks. Where the red earth is of great or fair depth, the area is agriculturally fertile. Where, on the other hand, this strata is shallow and the gravel layer outcrops on the surface through erosion and other causes, or where it has been subjected to severe weathering, as is the case with the cinnamon soils, the soils are notoriously poor. Geology as a soil-characterising agent is best exemplified in the case of the Jaffna and other soils associated with limestone parent material. The uniform, free draining, deep red soils, similar to the *terra rossa* of the Mediterranean regions, to which these limestone rocks give rise, are quite independent of climatic influences. The alluvial deposits as are to be found along the valleys of rivers, or in low-lying paddy areas covered with the debris and fine wash from the surrounding hills, are other examples of soils bearing a close relationship to its geological origin. From their very nature, great variation in the actual composition of these soils is only to be expected, and the paddy soils of Ceylon furnish evidence of this.

The soils of the highlands and of the paddy areas furnish the best examples of the effect of topography on the character of local soils. In the former, severe erosion caused by the heavy and intense rainfall has depleted the soils, for most part, of the valuable surface soil, with its accumulation of humus, colloidal material and easily-available plant fertilising constituents. In the low-lying paddy areas, this wash from the hills is deposited. In these paddy soils the influence of water movement as governed by topography is seen to advantage. Typical paddy soils are generally, for the greater period of the year, either submerged under water or poorly drained, as far as ordinary arable soils go,

the water table being at or near the surface. As a result the soils are characteristically of the gley type, the lower layers being bluish grey to dark grey in colour and mottled brown by hydrated iron oxides. Under well-drained conditions, these soils make quite good arable loams. The up-country and the majority of the low-country soils are generally well drained.

From the standpoint of the soil scientist the crystalline rocks of Ceylon, whether gneissic or igneous, are of significance only in so far as they are geologically basic or acidic. The acidic members of either group like the granites or granulites, generally give rise to lighter coloured and textured soils, poor in lime, but likely to be rich in potash. The soils derived from the basic rocks like the norites, are darker red in colour and generally heavier in texture, while in regard to plant food constituents they tend to be rich in lime and poor in potash. The actual composition of the soil will however depend on the kind of weathering to which the rock from which it has been derived was subjected, and the subsequent pedogenic (soil-forming) processes it has undergone.

The potash contents of local soils are therefore variable, but, in the main, fair, with an average of about 0·2 per cent. except in the sandy deposits and light sandy soils which are markedly deficient in this constituent. Response of local crops to potassic manuring is not therefore generally marked, except on the latter types of soils. Calcium as free carbonate is conspicuous by its absence except in the soils of the Jaffna Peninsula and the neighbouring areas on the mainland, and in isolated areas where limestone outcrops on the surface. Soils overlying limestone, as at Nalanda, are however usually devoid of free lime. The intensive rainfall conditions would account for this deficiency. The total calcium content of local soils is generally poor, being on the average less than 0·2 per cent. Ceylon soils are very poor in replaceable bases, particularly calcium. This again is due largely to the heavy rainfall, the absence of free lime in most areas, and to the nature of the clay complex. The soils on the drier areas appear to have slightly higher replaceable base contents than those of the wetter regions. As a consequence, the soils of the wet zone generally show an acid reaction. Alkaline reactions are given by the limestone soils of the Jaffna type, and some of the dry zone soils. The paddy soils have a variable reaction.

There are no large deposits of phosphate minerals in Ceylon. The only phosphatic mineral found as an accessory constituent in very small quantities in the crystalline rocks, is apatite. As a consequence local soils are generally poor in phosphoric acid, though, except in the case of the sandy deposits, never without some reserve of this plant food constituent. The average may be regarded as less than 0·1 per cent. The other mineral constituents—iron, magnesium and manganese oxides which influence crop growth to some extent are found in more than adequate proportions in the majority of our soils, the exceptions being the light sandy soils.

To turn now to the organic matter contents of local soils in relation to the natural features discussed in the preceding sections. The climatic conditions over the greater part of the Island are such as to effect a speedy decomposition of the organic residues in soils where the drainage is satisfactory. Mohr [6] has found in Java that up to about a temperature of about 20°C. organic matter accumulates in the soil. Above this temperature "conditions are more favourable for the organic matter decomposing micro-organisms of the soil than for the higher plants which furnish the materials for these organisms to act upon, and the organic matter is destroyed as rapidly as it is supplied by plants." Local arable soils are therefore generally poor in organic matter, often containing less than 3 per cent. of this constituent, the exceptions being the soils of virgin forests, grassland areas (*patanas*) and fernlands (*damanas*) where amounts of this constituent up to 8 or 10 per cent. may be found. Under cooler conditions, and where the soil is constantly kept moist, as in the Nuwara Eliya District, accumulations of organic matter take the form of peaty deposit of from 2 to 5 feet depth in certain locations. Under anaerobic conditions, as in paddy soils, the organic matter contents are generally higher, and in small areas deposits of low-lying acid peat sometimes extending to 15 feet in depth are to be found. The best examples of such peaty deposits are to be found in the gemming areas of the Island.

The nitrogen content of local soils varies considerably, the average being about ·15 per cent. ranging from ·6 per cent. in the humus up-country soils, to ·01 per cent. in the sandy soils. The soils of the drier regions have generally lower nitrogen and organic matter contents than those of the wetter districts.

Taken as a whole the soils of the Island are by no means rich in mineral and organic plant food reserves. Numerous soils exist which are definitely poor in both respects. The low-lying paddy soils are generally richer in both mineral and organic plant food than the ordinary arable soils, but this is only to be expected as they contain the valuable eroded material of the neighbouring high lands. The soils of the Island being intrinsically poor, it may well be asked what the reason for the luxuriance of the local vegetation is. This is to be sought in the favourable light intensity and the high temperature and rainfall conditions generally experienced in Ceylon. As a consequence, photosynthetic activity is at an optimum. So also is bacterial activity, making quickly available the plant food reserves of the soil or what is added to it as organic matter. As Ramann[7] states: "Most tropical soils are deficient in plant nutrients and are in great need of manures. The foliage, which falls continually throughout the year, decays rapidly and the liberated plant nutrients circulating very rapidly suffice for the great luxuriance of the tropical forest. On the whole, the tropical forest works with a small capital of nutrients and a rapid turnover". Tennent [8] as early as 1860 writes in regard to local soils, not without reason, that "the soil notwithstanding its wonderful display of spontaneous vegetation, is not responsive to systematic cultivation and is but imperfectly adapted for maturing a constant succession of seed and cereal crops". Manuring of most local crops is generally required if continued good yields are to be obtained. With the view of the general poverty of tropical soils Vageler [9] is in agreement when he states that the "inexhaustible richness of tropical soils is but seldom found in Nature."

GENERAL CHARACTERISTICS OF THE MAJOR SOIL GROUPS OF CEYLON

The general characteristics of the more important soil groups or associations of the Island will now be considered. These groups, so far as our present knowledge goes, are as follows:

1. The laterite soils, lateritic soils, (red and yellow earths), and the non-lateritic red, yellowish red and brownish red loams. Red soils occur in both wet and dry regions.

2. Immature pale-brown loams of the humid mid-country and other immature soils.

3. The red and chocolate red soils associated with calcareous rocks, either sedimentary as in the case of the Jaffna soils or metamorphic, as in the case of the Nalanda group. These soils are comparable to the *terra rossa* of the Mediterranean regions.

4. The *patana* (grassland) and the *damana* (fernland) soils of the wet regions. These may be compared to the mountain peat world type.

5. The dry *patana* soils, which may be classed as tropical mountain steppes or savannahs.

6. Soils derived from "plateau" and alluvial deposits. These include the white cinnamon soils (dune soils), the pale-brown to red and chocolate-coloured sands and loams, and the gravelly soils.

7. Permanent and seasonal ground water soils. These include all the reddish brown to dark-grey paddy soils, the *talawas* (low-lying meadow soils), and the saline soils. The paddy soils could be suitably classed as *gley* soils.

8. The low-lying peat deposits associated with certain paddy and gemming areas.

9. Soils similar to the black cotton soils of India.

GROUP I

Laterite Soils.—These soils are derived directly from laterite, which is the residual product of the weathering mainly of basic and intermediate igneous and metamorphic rocks (gneisses) of the hot, moist low-country. Their constituents are mainly the sesquioxides of iron and aluminium, and crystalline quartz. The following analyses of local laterite samples by Bamber and Bruce will afford confirmation of this.

		I	II	III
Moisture & combined water per cent.		27·2	16·2	31·7
Iron oxide	,,	17·8	29·0	4·0
Alumina	,,	33·7	12·3	32·6
Insoluble matter	,,	22·0	42·7	33·0
Containing Alumina	,,	18·5	10·6	29·3
Silica	,,	3·5	30·0	3·7

Laterite is quarried to depths of as much as 30 to 40 feet and occasionally greater. The surface of these pits is generally mantled with concretionary gravel embedded in a matrix of fine clay of depth varying from 2 to 6 ft. The uppermost layer of laterite is hard and scoriaceous, but the hardness rapidly decreases with depth. The lowest horizon consists of very soft laterite containing large proportions of a yellowish-white clayey material (chiefly hydrated aluminium oxides) in the interstices. Laterite soils are chemically very poor, a typical soil examined showing only ·05 per cent. nitrogen, ·006 per cent. potash and ·001 per cent. phosphoric acid. They are acid in reaction. In certain areas the gravelly surface layer is altogether absent and the underlying soil, if so it can be termed, is hard and impervious to water. Root penetration is therefore impossible and crop failures often result. In other areas, however, the laterite has in turn undergone disintegration and given rise to porous gravelly soils of generally low fertility.

Lateritic and Non-Lateritic Red and Yellow Soils. (Red and Yellow Earths and Loams).—The great majority of the wet low and up-country soils of Ceylon may be classed as lateritic soils. They are deep, compact soils with colour variations, both within and between profiles, of red and pinkish red to reddish yellow and yellowish brown. Like laterite soils, they are usually formed from igneous and metamorphic rocks, mainly gneisses, *in situ*, but the laterisation process is only partial. The upper surface layers, especially of virgin soils, are brownish in colour due to the admixture of humus. There are, otherwise, no distinct horizons in these soils. The cultivated soils are generally poor in organic matter, but the nitrogen contents are variable. Potash contents vary but are generally fair, and phosphoric acid generally low. The soils are very poor in replaceable bases. In reaction they are acid. The soils vary in texture from sandy to clay loams and generally show increased clay or silt contents with depth. Analyses of the clay fractions for silica and alumina indicate that these red soils are, on Martin and Doyne's [11] criteria, either non-lateritic (red loams) with molecular ratios of silica to alumina greater than 2, or more generally lateritic (red earths) with ratios between 2 and 1·33. The former may be regarded as immature lateritic soils. These soils when well-cultivated are generally fertile, especially the red loams. They are sticky and plastic when wet, hard and

cloddy when dry. They drain fairly well because of the ferruginous and quartz gravel invariably associated with them. The gravel constitutes in certain areas a very high percentage of the soil mass, which is then of poor agricultural value. The up-country lateritic soils are similar to those of the low-country. Analyses do not reveal any appreciable differences between the red and yellowish soils except in regard to the iron oxide contents which appear to be higher in the clay fractions of the yellow soils. The colour variation is apparently due to differences in the nature of the hydrated ferric oxides in the soils. The pinkish soils have generally higher proportions of manganese oxide than the red and yellowish soils. These soils are suitable for a number of agricultural crops, particularly tea which requires acid soil conditions and rubber, but coconuts and other crops are also grown on them. For more detailed information on red soils reference may be made to a paper by Hardy [10] and to Vageler's book on tropical soils [9].

Dry Zone Red Soils.—The red to yellowish red soils of the dry zone also vary in texture from light sandy to heavy loams, and contains high proportions of gravel and quartz. They are mainly derived from the underlying rock but some are doubtless the residual red earth material of the plateau deposits. The uppermost horizon of these soils is of a red-brown colour due to the presence of humus, but the content of this material is generally lower than that of the wet zone red soils. The replaceable bases are of the same order, but the soil reaction is not so acid. The mineral plant food constituents vary, but generally appear to be slightly higher than in the soils of the wetter region. Owing to the lower rainfall their availability may however be lower. These soils drain well. They are generally non-lateritic in nature. They respond fairly well to cultivation with annual crops for the first two or three years, but subsequent yields are low. This has led to the development of a practice known as *chena* cultivation, in which crops are grown on recently felled and burnt jungle land for a year or two and then allowed to remain fallow for about six or seven years. At the end of this period the land is re-cultivated. Agricultural experiment has demonstrated that this wasteful practice can be advantageously replaced by a system of crop rotation. For the securing of continued good yields, however, manuring is essential.

GROUP II

THE IMMATURE LOAMS

In the mid-country at elevations up to 1,800 feet or thereabouts, fairly large extents of a pale-brown to pinkish-brown micaceous silty loam occur interspersed between the more mature red earths and loams. These loams are often very deep, porous, free-working soils, particularly devoid of concretionary material. They show no horizon development and are characterised by the presence throughout of thin flakes of brown mica. They appear to be formed *in situ* from micaceous gneisses. They are rather soapy to the feel when wet and do not dry hard. Analyses show them to be comparatively fair in mineral fertilising constituents but poor in organic matter. They are fairly fertile when well cultivated, though occasionally areas of poor agricultural value occur. They are obviously immature soils. Of not infrequent occurrence both up-country and low-country are soils, often of fair depth, consisting of recently-weathered rock. The strata of the latter are often clearly discernible in the soil profile. These 'rock brash' profiles are generally grey to pale-brown in colour and mottled white by decomposed felspar. They drain well, being loose and friable, and are deficient in clay, organic matter and available mineral constituents. They however break down to normal soil, comparatively quickly, under the intense weathering conditions of the tropics.

GROUP III

THE RED SOILS ASSOCIATED WITH LIMESTONE

In Ceylon these red soils are associated with two distinct geological formations. By far the more important of these are the soils of the Jaffna Peninsula and the north-west coast of the Island formed from sedimentary limestone, largely calcium carbonate. The soils vary in texture from light to heavy loams. The former, which are in the majority, are deep and well drained and generally of a brick red colour. The clay loams vary in colour from yellowish brown to deep chocolate, and are also fairly deep. These red soils are non-lateritic in nature. Free calcium carbonate is not frequently found in them, especially in the surface soils of very intensively cultivated areas, and when present is due to marine residues. Their exchangeable base contents are very high. The soils are alkaline in reaction and well supplied with phosphorous and lime. Nitrogen is low and so also the organic matter content. Potash is high in the

medium loams and very high in the clay loams. These soils are cultivated with a variety of crops under irrigation, and give good yields. Tobacco, vegetables and fruits are grown on the lighter soils; paddy, tobacco and other crops on the heavier loams.

The other group of limestone soils is that associated with and overlying the crystalline limestones, mainly dolomite, which occur in small areas in a number of districts. Of these areas the Nalanda-Dambulla district furnishes the most characteristic soil types. The soils are dark-red to chocolate, deep, free-working loams, showing no horizon delimitations. They are very well drained. Free carbonate is generally absent. The soils are similar to the red earths and loams, but are less compact, more friable, and not so sticky. They are well supplied with fertilising constituents particularly exchangeable bases, are generally slightly alkaline to neutral in reaction, and are quite fertile. They generally contain ferruginous concretions, which occasionally constitute a high proportion of the soil. With adequate rainfall or irrigation they can be made to grow a variety of crops.

GROUP IV

THE WET PATANAS AND DAMANA SOILS

The *patanas* or grasslands occur in fairly large extents in both very humid as well as moderately humid up-country districts. They have a very characteristic appearance. The vegetation of the wet patanas which occur at elevations of over 4,500 feet., consists mainly of coarse tufted grasses of which a common variety sometimes known as Gawara grass (*Chyrsopogon zeylanicus*). Bracken (*Pteris aquilina*) is common. Characteristic temperate species are also found. The only tree known to flourish in these patanas is *Rhododendron arboreum*. The rainfall and temperature conditions under which these patanas are developed are ideal for humus accumulation, the average temperature being about 60°F. and the rainfall about 98 inches fairly uniformly distributed over the year. The surface layer of the patanas extending to about 5 or 6 feet in depth occasionally, is a dark, friable soil containing a peat-like material. Its organic matter content is occasionally as high as 15 per cent. This layer is generally moist. Immediately underlying this is the B horizon of quartz and concretionary gravel in a dark-brown loamy matrix. The lowest horizon is a yellowish red compact

clay loam extending down to 15 feet and more. The wet patana soils are not well drained, owing to the heavy, compact sub-soil layers. The analytical examination of a characteristic wet patana profile shows that the soil horizons are distinctly acid. They contain fair quantities of phosphoric acid, but are poor in potash. The nitrogen content of the surface layer is high, but the B and C horizons are very poor in this constituent. The replaceable base contents are low. The results of clay analysis of soil samples from a patana profile at Kandapola, show them to be laterite soils, the silica/alumina ratios being about 0·8. It is likely, however, that soils of other similar profiles will be of the lateritic type. The patana soils make good tea soils when cultivated, but in the course of a few years the rich humus layer is entirely destroyed either through erosion or decomposition. In the depressions of the hills, the patanas give place to forest. For a full account of the patanas of Ceylon and of the theories of their origin, reference to Pearson's paper should be made [13].

Similar to the patanas of the up-country are the *damanas* or fernlands also known as *kekilla* lands of the moist low-country. Fernlands or bracken lands are also found to some extent in up-country and mid-country districts, where they are of good agricultural value. The ferns mainly found in the low-country *damanas* are *Gleichenia linearis* and *Nephrolepsis exaltata*. The grass *Themeda tremula* also occurs in the poorer areas. The dark-brown humus surface soil layer of these *damanas* is occasionally over a foot deep. The layer below this is a lateritic gravel, underlying which is a reddish gravelly loam containing boulders of undecomposed rock. The organic matter and nitrogen contents of the fernlands are not as high as those of the patanas, percentages of the former over 6 being rare. The soil layers of characteristic profiles examined show good reserves of potash, but poor phosphoric acid and replaceable base contents. The reaction is distinctly acid. The soils belong to the lateritic type and are amenable to cultivation with certain perennial crops, but are not suitable for annual crops.

GROUP V

THE DRY PATANAS

These patanas, comparable to mountain steppes or savannahs, extend to the east of the high mountain ranges between 2,000 to 4,500 feet altitude, over a large area which experiences

rainfall only during one season and a fairly long season of drought. They are the chief feature of the Uva Province. The average rainfall of the area is about 55 inches, most of which falls during the three months of the North-East Monsoon. The average temperature is about 70°F. with a fairly wide range of variation. The vegetation chiefly consists of coarse wiry grasses of the genera *Panicum*, *Imperata*, *Andropogon*, *Aristida*, etc., characteristic of the *savannahs* in other parts of the world. Several reasons have been assigned for the nature and origin of the Uva patanas. These are: shallow and poor soil, the outcropping of rock on the surface, lack of soil moisture, the incidence of rainfall and the long period of drought, patana fires, erosion and wind. It would suffice merely to state that each of these factors has perhaps influenced the formation of these steppes to some degree. Forest vegetation is largely confined, as in the case of the wet patanas, to the depressions and occasional crests of hills. Soil is absent over the greater part of these patanas, but areas of well-developed, deep soil, often of large extent, do occur. These areas are associated with bracken (*Pteris aquilina*). They have been found suitable for systematic cultivation, chiefly of tea and fruit. Where well developed, a dry patana soil profile exhibits a fairly high, humus-containing Ao horizon of varying depth, overlying a reddish-brown gravelly loam containing concretionary material and undecomposed boulders. The Ao horizon is absent in cultivated soils. The lower horizons are reddish and yellowish loams. Organic matter and nitrogen are fair in the A horizon but low in the others. All soil layers are poor in mineral constituents, slightly acid in reaction, and on the basis of the silica/alumina ratios of the clay fraction, lateritic in nature. The degree of laterisation of the patana soils is apparently connected with the rainfall conditions, being greater the higher the rainfall and more even its distribution. Craig and Halais [12] afford evidence in confirmation of this observation with Mauritius soils generally. The replaceable base contents of the dry patana soils, though low, are slightly higher than those of the wet patanas. The economic utilisation of any extent of patana country for agricultural or pastoral purposes will be dependent on a number of factors, but soil conditions would doubtless be the limiting factor in the greater part of the area

GROUP VI

SOILS DERIVED FROM THE "PLATEAU" AND ALLUVIAL DEPOSITS

The soils derived from the 'plateau gravels' to which reference has been made are as follows:

(a) The pale-brown to red and chocolate-coloured sandy and medium loams, and the grey-brown heavy loams.

(b) The cinnamon soils (dune soils).

(c) The gravelly soils.

(a). *The Light Sandy and Heavy Loams.*—The pale-brown to red and chocolate-coloured loams occur in the maritime regions of the Western and North-Western Provinces, and extend for some distance inland. They are mostly light sandy to medium free-draining loams, frequently of great depth. They show no very marked variation in profile characteristics, except that the surface layer is darker in colour owing to the addition of organic matter and of lighter texture. Underlying the main soil mass, often at great depths, is a clayey layer or the undecomposed rock. These soils are generally poor in fertilising constituents chiefly potash and phosphoric acid, and of slightly acid reaction. Exchangeable base contents are low. The soils are very suitable for coconuts, which are extensively cultivated in the districts they occur. Occasionally small extents of grey-brown heavy loams are found among the lighter soils. Both types of soils appear to be derived from the plateau gravel red earth plateau deposits, the finer particles of which have been in the case of the lighter soils eluviated to lower depths, leaving a quartz deposit occasionally coloured red by oxides of iron. Various types of soils of this series exist even in a comparatively small area. These soils are generally non-lateritic.

(b). *The Cinnamon Soils (Dune Soils).*—These are, according to Wayland, completely bleached red earth residual products, consisting of over 95 per cent. fine quartz and sand. The soils are considered to have been formed under swamp conditions. They are extremely poor in fertilising constituents. At varying depths extending to 6 or 8 feet, depending on the depth of the water-table, a blackish brown pan-like layer is observed. This contains accumulations of humus and sesquioxides leached down from the surface layers. The soils are acid in reaction.

In these respects these soils bear a close resemblance to the *podsols* of the humid temperate zones. Coconuts are grown on them, but require considerable additions of organic matter and potash to give good yields.

(c). *The Gravelly Soils.*—These soils are in reality the 'turtle backs' of the plateau gravels, from which the red earth surface stratum has been eroded. They are distributed in well defined directions between the light sandy loams described in a previous section. The gravel consists of either quartz or ferruginous concretions in a matrix of reddish clay. The percentage weight of gravel in the soil mass is very high, being in certain cases over 75 per cent. Root development on these soils is therefore poor and crop growth is affected accordingly.

The alluvial deposits, which are of more recent geological origin than the red earths, are generally confined to the more low-lying areas. They vary in depth and texture, all types of soils from sands to heavy loams being encountered. The latter are greyish brown in colour, fairly well supplied with organic and mineral plant food constituents, particularly the latter, and are often imperfectly drained. Deep drainage is therefore essential on these soils, which, if so treated, are rendered of high fertility.

GROUP VII

PERMANENT AND SEASONAL GROUND WATER SOILS

The permanent and seasonal ground water soils include the paddy soils of the Island and the *talawas* or low-lying meadow soils. In addition there are comparatively small areas of saline soils, confined mainly to heavy, low-lying paddy areas in the dry districts and the marshes adjoining the lagoons. Soil drainage is poor in these heavy soils, temperatures very high and rainfall low. Salt is therefore deposited as thin films on the soil surface during the dry weather through capillary action. The Hambantota and Puttalam districts and the Wanni furnish good examples of saline soils. The maximum total soluble salt content of one field on which paddy failed was 1·48 per cent. against an average of ·08 per cent. in well drained soils in the wet zone. The salt marsh areas are scattered over the Island and occasionally cover wide stretches of land. They are of no agricultural value.

The Paddy Soils.—The paddy soils of the Island generally occupy the flat low-country areas and the low-lying depressions between hills. Occasionally the crop is grown in terraced fields on the slopes of the hillside, but the proportion of land so cultivated is small. These soils are for the most part only seasonally under water, being irrigated artificially during the dry season in many cases. In a few areas, however, the soils are constantly ill-drained or water-logged. These are the *deniya* soils. Paddy soils range in texture from light sandy loams to heavy clays. In one case a clay content of over 76 per cent. was found. The average clay content of the paddy soils of the Island is however low and most of these soils will fall under the class of sandy to medium loams. Underlying the surface soil of 6 to 8 inches, which is the region of root development, is a sub-soil of much heavier texture than the surface layer. This is the result of years of puddling up to the depth of cultivation, with the object of retaining the soil water for as long a period as possible. Drainage in paddy soils is imperfect, but nevertheless existent. These soils during the cultivation of the crop are typical 'gley' soils. The surface soils vary from a dark-brown to grey-black colour, while the sub-soils are generally of a greyish to blackish tint, mottled and streaked reddish-brown by the hydrated iron oxides. The colour of the sub-soil is due to the anaerobic conditions obtaining therein.

Chemically, local paddy soils have, on the average, fair quantities of plant food constituents compared with those of other paddy-growing countries. Our soils are generally poor in potash and lime, and to a lesser extent in phosphoric acid, but contain fair quantities of nitrogen. They range in reaction from acid to slightly alkaline. Calcium carbonate in small amounts is very occasionally present. Physically, Ceylon paddy soils are lighter textured and of poorer water-holding capacity than those of other countries. For further information, reference may be made to Bruce's paper [14].

Under the sub-head of seasonal ground water soils may be classed the soils of the *talawas*, low-lying, park-like meadows of the semi-humid, hot low-country. These meadow lands occur between forest land, mainly in the country watered by the Mahaweli Ganga and other rivers flowing to the East. The soils are mainly loams and generally make good pastureland. Occasionally they are subjected to temporary water-logging and flooding.

GROUP VIII

LOW-LYING PEAT DEPOSITS

These low-lying peat deposits are associated with paddy soils or gemming areas characterised by the presence of excessive moisture. In some of the latter an acid peaty deposit of 1 to 20 feet overlies a gravel, termed *Illam*, in which gems are found. On the surface of the peat is an earth crust, 1 to 3 feet deep. Paddy is occasionally cultivated in these areas. An analysis of a sample of the peaty deposit showed it to contain, on air-dry material, 60 per cent. of organic matter, 28 per cent. ash and 12 per cent. moisture. The nitrogen content was 0·8 per cent., lime 1·7 per cent. and phosphoric acid 0·1 per cent. The peat was distinctly of the acid type, its reaction being 4·7.

Peaty deposits of much less depth also exist in low-lying paddy soils in certain districts like Matara in the Southern Province and Negombo in the Western Province. The peat in these cases is again of a distinctly acid nature and similar, chemically, to the gem field peats. These low-lying acid peats do not however occupy extensive areas.

GROUP IX

SOILS SIMILAR TO THE BLACK COTTON SOILS OF INDIA

These soils [15] are reported to be dark-grey to black silt loams of clodular structure, situated in the Mannar district near the village of Tunnekai and occupying an area of about 16 square miles. They are considered to be very suitable for cotton cultivation, being from 10 to 15 feet in depth. The soils are neutral to alkaline in reaction, rich in lime, fair in potash and poor in phosphoric acid. The nitrogen and humus contents are generally poor. Owing however to difficulty of access, no cotton-growing experiments were undertaken. The soils compare favourably with the black cotton soils of the Madras Presidency.

SCHEME OF CLASSIFICATION

Now that the characteristics of the major soil groups of Ceylon, as at present known, have been described, though somewhat sketchily, it would be quite pertinent and of some advantage to draw up some sort of scheme, based on recognised world systems of classification, into which local soil groups might be fitted. In the scheme suggested, following the method of

Robinson [16], consideration is first given to the question of drainage. The soils are divided into two large classes according as to whether the drainage is free or impeded. Each class is then subdivided into various geological soil groups and a further subdivision effected, based on climatic differences.

This scheme is only provisional and may require considerable modification. But it is attempted in the hope that it will lead to a wider and more intensive study of local soil groups and later, of soil types. Should any reader of this article know of any other important group of soils of the Island which has not been dealt with in this paper or referred to in the scheme, the writer would be pleased if such could be brought to his notice for investigation and future study. In the papers that follow the results of profile examinations of some of these soil groups will be detailed.

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TENTATIVE SCHEME OF CLASSIFICATION OF CEYLON SOILS

A. SOILS WITH FREE DRAINAGE

Under Humid Conditions	*Under Semi-Arid Conditions*
1. (a) Laterites (b) Lateritic soils (Red and yellowish earths) (c) Non-Lateritic soils (Red and reddish yellow loams of low and upcountry).	1. Red earth and loams of the dry zone.
2. Immature soils.	2. do do
3. Red and chocolate red soils derived from overlying crystalline calcareous rocks (*Terra rossa*) (*Nalanda* series).	3. Red soils derived from sedimentary limestone (Jaffna series).
4. Residual soil derived from 'Plateau Deposits'. (a) Reddish, pale-brown and grey sandy loams. (b) Cinnamon soils (Dune soils). (c) Gravelly soils.	4. (a) Red loams and gravels derived from 'Plateau Deposits' (b) Black cotton soils.
5. Soils derived from recent alluvium.	5. do do
6. Absent.	6. Dry *patanas* (tropical mountain steppes).

B. SOILS WITH IMPEDED DRAINAGE

1. Permanent and seasonal ground water soils : (a) Paddy soils (Gley soils). (b) Wet *patanas* (Mountain peats). (c) *Damanas* (Fernlands and bracken land). (d) Forest alluvial soils.	1. Permanent and seasonal ground water soils : (a) do (b) *Talawas* (c) Saline paddy soils and salt marshes.
2. Low-lying acid peats.	2. Absent.

DISEASES OF THE BANANA*

BUNCHY TOP

BUNCHY Top differs considerably from the usual conception of a plant disease. It is not caused by a fungus or bacterial parasite, but an infectious agent or virus which is very much smaller than either of these. Although this virus cannot be seen by even a high powered microscope, it is known to live and multiply in the sap of the diseased plant. In most virus diseases the affected plant has no definite lesion such as a spot or rot, but is usually stunted and abnormal in foliage or fruit development.

In the case of bunchy top the leaves formed after infection are short and narrow with the margin distinctly up-curved. They fail to bend over normally and retain a stiff erect habit which, combined with the fact that the leaf stalk is greatly reduced in length, gives the characteristic rosetted appearance to which the disease owes its name. The foliage on such plants is crisp and brittle when crushed. A bunch is rarely produced unless infection has taken place late in the life of the plant.

Effective control of bunchy top necessitates recognising the disease in its early stages. A plant should be regarded with suspicion if the youngest leaves exhibit a light-green colour along the edge and have blades which dip back sharply from the midrib and curve in again conspicuously from the margin. A definite and unquestionable diagnosis can then be made by examining the base of the youngest leaf from the underside and with the light behind it. If the plant is infected there will be seen narrow dark-green lines, broken in a dot and dash manner or sometimes continuous, lying between and parallel to the clear veins which run out at right angles to the midrib. There is also often one or more wide dark-green streaks running down the outside of the leaf stalk near its junction with the pseudostem.

Bunchy top is spread in the plantation by the banana aphis when it sucks the virus-infected sap of a diseased plant and then leaves it and feeds on a healthy one. Aphids may travel considerable distances in the air, and this accounts for isolated outbreaks of bunchy top in plantations otherwise free from the disease.

In a single stool the virus from a diseased parent plant may travel in the sap stream down to the corm and thence out through the connecting tissue to the young suckers, which will in turn develop the disease, usually remaining in a stunted and rosetted condition. The possibility of sucker infection has an important bearing on the control measures discussed below.

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* By J. H. Simmonds, M.Sc., Plant Pathologist in the *Queensland Agricultural Journal*, Vol. XLIII, Part 3, 1 March, 1935.

CONTROL

There is no known method of destroying the virus in the plant without destroying the plant itself, and hence anything in the nature of a cure is impossible; nor is it commercially practical to destroy all aphids in a plantation and so limit the spread of the disease by this means. It, therefore, becomes necessary to concentrate on eliminating the source of supply of the virus by exclusion and destruction of diseased plants.

Firstly, care must be taken that all suckers used for planting are free from bunchy top infection. The agents of the Banana Industry Protection Board are in a position to advise growers where suitable planting material may be obtained. They should also be consulted regarding the current planting policy, as a planting permit may have to be refused if the spread of bunchy top or other disease or pest is involved.

Secondly, diseased plants must be destroyed as soon as they show the first symptoms of infection. Thorough inspections should be made for the purpose of locating bunchy top plants. The frequency of these inspections will depend on the amount of bunchy top present, and must ensure that in every case the diseased plant is found as soon as the infection becomes recognisable. Eradication must follow immediately, and to be effective the following procedure should be followed:

To prevent aphids leaving the diseased plant for a healthy one first pour not less than half a pint of pure kerosene into the central leaf of the affected plant and other plants connected with it in the same stool. Wait for a few hours to allow the kerosene to trickle down round the leaf bases and so kill all aphids present. Then dig out the stool including the infected plant and any others connected with it, and chop into small pieces to facilitate drying.

HEART ROT

A second virus disease of bananas is now known to occur in this State. Although this disease is widely distributed throughout Southern Queensland it fortunately has not exhibited the capacity for rapid spread that has made bunchy top so serious. The characteristics of the disease vary at different times of the year. The most general symptom is a chlorotic condition of the younger leaves formed by light-green to yellow streaks or bands which extend out from the midrib. These streaks may be narrow and interrupted so that a mosaic effect is produced. During the colder months a soft black rot may involve the funnel leaf and develop down into the heart of the plant. If this rot reaches the corm the whole plant may die. Often, however, with a change in environmental conditions the extension of the rot will cease, but the new leaves coming away may be narrow with irregular and blackened edges resulting from the previous rotting of their margin. As in the case of bunchy top the virus may pass from a diseased plant to the suckers with the production of a stunted and heavily mosaic-marked plant.

The cause of heart rot was first investigated by Magee in New South Wales. He showed that the disease was due to an infectious virus which was carried from infected to healthy plants by the banana aphis. Heart

rot therefore resembles bunchy top in this respect. As would be expected, the control measures advocated in the case of the latter have so far effectively checked the spread of the former disease. Briefly, the recommendations are as follows:

1. Plant only disease free suckers.

2. Kerosene and dig out an affected stool immediately heart rot symptoms are noticed.

LEAF SPOT AND SPECKLE

Although leaf spot and speckle are probably distinct diseases they will be considered together here since they are usually both present in the plantation, and the final effect on the plant is very similar in each case.

Leaf spot is caused by the fungus *Cercospora musae*. It is a disease which is widely distributed outside Queensland occurring as it does in India, the Eastern Tropics, and Fiji. The spots are easily recognised and are most prominent on the upper surface. They consist of narrow, oblong, or elliptical, brown to black, areas about half-an-inch long by an eighth in width. With age the centre dries out leaving a characteristic grey spot bordered with a black line and surrounded by a yellow halo. Usually the grey spots are still easily distinguishable after the leaf has dried out. Minute greyish tufts of fungus spores can sometimes be seen on the surface of the spots following prolonged rainy weather.

Speckle is found on the under surface of the leaf as scattered or aggregated dark brown to black blotches of varying size and intensity. These dark patches are formed in the first place by a close speckling of the surface with greyish dots which later darken and coalesce. The cause of speckle is not as yet definitely known, although it is evidently of fungus origin. Its distribution is as wide as leaf spot.

Leaf spot is usually most abundant towards the outer end of the leaf, whilst speckle is, if anything, more prevalent towards the base. A shaded situation may definitely favour the development of the latter, but not the former. With both diseases the lower leaves are attacked first, and if the spots are numerous the individual lesions will coalesce and form large peninsulas of dead tissue extending from the margin in towards the midrib. Eventually the whole leaf will dry out. This results in a gradual defoliation of the plant from the base up and under average plantation conditions on growing plants an equilibrium is reached at which there are usually three leaves unaffected and four to five with leaf spot and speckle present in increasing intensity from above downwards. This is apparently sufficient leaf area to support the growth of the plant, and it is doubtful whether the initial size of the bunch when thrown is greatly affected by these leaf diseases. However, once the bunch is out no further leaves are formed, and the gradual invasion and consequent death of those present deprives the bunch of its normal shelter, with the result that the fruit often fails to develop properly and may become badly scalded.

Leaf spot and speckle are usually present at all times of the year, the relative importance of each varying somewhat with environmental conditions. Both diseases are favoured by wet weather, but in the case of

leaf spot three or more days of continuous rain during the moderately warm weather of February, March, or April appears necessary for an epidemic outbreak. The leaf defoliation is most serious during the winter months when growth is at its slowest. In the spring the situation changes and the plants tend to outgrow the disease. Conditions such as poor drainage, unsuitable soil and aspect, cold and heavy weevil borer infestation will add to the seriousness of leaf disease by retarding the growth of the plant, and even on their own account in the absence of disease may be responsible for abnormal leaf fall.

CONTROL

From the above discussion it will be seen that the maintenance of a continuous vigorous growth will help towards reducing loss from these diseases. In this connection it must be remembered that the banana is essentially a tropical plant and greatly affected by cool temperatures. The broad flexible leaves and other growth characters indicate that adequate shelter from strong winds and abundant and evenly distributed moisture are necessary. The roots are adapted to a loose well-drained soil adequately supplied with humus, and will suffer if exposed to extreme variations of wet and dry conditions. The provision of adequate windbreaks and the safeguarding of the better surface soil from erosion during the heavy summer rains by means of terracing, cover-cropping and other modifications of the usual cultural practice will greatly assist in maintaining the productiveness of a banana plantation, in spite of the presence of disease.

Direct control of the leaf diseases by fungicides is made difficult by the nature of the banana plant itself and the inaccessibility of most plantations. Dusting has been proved to be ineffective, probably owing to the difficulty of obtaining a permanent cover on the shiny leaf. Bordeaux mixture applied in February and March with a suitable spreader will check speckle and to a lesser extent leaf spot, but it is doubtful whether the final results obtained justify the trouble of spraying such a crop as the banana.

Perhaps the most practical method of reducing the loss due to leaf defoliation is to protect the developing bunch from exposure by covering it with bagging. Two methods are available. The bunch may be entirely enclosed in a hessian bag of suitable size. This procedure results in the greatest final benefit, but the slowness of the operation and the difficulty of determining the correct cutting maturity are decided disadvantages. In the second method half a corn sack is used. This is rapidly thrown over the exposed side of the bunch and secured behind with a nail. All bunches likely to be exposed should be covered as soon as the fruit commences to fill out, the correct time being largely a matter of experience. In order to provide for the heavy defoliation in winter and spring bagging should commence in April and continue throughout the winter so long as bunches are left without leaf protection.

YELLOW LEAF SPOT

This leaf spot is serious only in the northern parts of the State, where it may cause leaf defoliation in a manner similar to *Cercospora* leaf spot. The disease commences on the lower leaves as indefinite light yellow areas.

These take up an elliptic or more characteristically a definite diamond shape, turn deep yellow, and then gradually darken in the centre where they dry out to dark brown, leaving a narrow but distinct yellow margin. These spots, except in the very earliest stages, are considerably larger than those caused by *Cercospora musae*, and may be as much as 3 to 4 inches long by 1 to 1½ inches broad. Young plantations may suffer badly from yellow leaf spot, whereas they are usually free from severe attacks of the other leaf diseases.

Yellow leaf spot is apparently caused by the fungus *Cordana musae*, whose fructifications form a greyish down covering the under surface of the spots. This organism is widely distributed throughout tropical countries, but is not usually considered of as much importance as in Queensland, where severe defoliation has been known to result from its presence.

In plantations where yellow leaf spot is serious the protection of the fruit from scalding by the method described in the case of leaf spot and speckle should give some relief.

PANAMA DISEASE

Panama disease affects only the tall-growing varieties, such as the Sugar, Lady's Finger, and Gros Michel. It is widely distributed throughout the world and has received its name from the region where it was first known to cause serious loss. The presence of the disease is indicated by the development of a deep yellow colour round the margin of the lower leaves, which later turn brown and dry out. The leaf stalk collapses, leaving the dead leaves in a gradually increasing number draped round the pseudostem.

A definite diagnosis of Panama is made by splitting up the base of the plant lengthwise, when the corm will be found discoloured by numerous brown to black lines running in all directions through the white tissue. The brown vessels can usually be followed up through the sheathing leaf bases and out into the vertical partitions of the leaf stalk. The reddish-brown lines in the latter situation are often a means of quickly identifying the disease.

Panama diseases is caused by a fungus (*Fusarium cubense*) which is capable of living for some time in the soil and when a suitable opportunity offers may infect the banana plant by means of the roots or wounds in the corm. It then travels up the water conducting vessels causing the black lines already referred to. The fungus may grow out through the tissue connecting a diseased parent with the surrounding suckers, and the planting of such infected material is one of the chief means by which the disease is spread.

CONTROL

The only satisfactory way of dealing with Panama disease is by a combination of exclusion and eradication.

1. Only land which has not previously grown bananas or on which the disease has never occurred should be planted with susceptible varieties.

2. Obtain planting material only from a district in which Panama does not exist.

3. A plant may become infected by wind-borne spores, or by infectious material accidentally introduced on boots and farm implements. Immediately a plant shows signs of infection the whole stool should be dug out, chopped into pieces and burnt on the spot. Any instrument used in cutting a diseased plant should be washed in formalin solution or passed through a flame before using it on a healthy plant. It is unwise to replant in the same spot.

4. Unfavourable soil conditions, especially poor drainage, greatly increases the severity of Panama attack and, conversely, the provision of optimum conditions of growth for the fruit will help to diminish the loss from this disease.

DRY ROT

Dry rot is not a disease of serious consequence, as only an isolated plant or a small group of plants is usually attacked. In an affected plant the leaves commence to die back from the margin and eventually the whole of the foliage becomes brown and dry. The pseudostem may be easily pushed over owing to the absence of sound roots. The normal corm tissue is largely replaced by a more or less dry, punky substance of a dirty white to brown colour. This consists of a mass of closely interwoven fungal threads which have invaded the corm and largely replaced the plant tissues.

Dry rot is caused by certain of the mushroom and bracket fungi, including a *Poria*, all of which live for the most part on dead and rotting stumps such as are present in abundance in the average banana plantation. From here it is possible for them to pass to a living banana plant should one be growing in close proximity and by invasion of the corm produce the dry rot described above.

In order to prevent the spread of dry rot to adjacent stools it is advisable to locate, if possible, the stump or roots from which infection has proceeded and remove and burn this material together with the infection corm.

CIGAR END

Cigar end is a trouble affecting relatively young fruit in the plantation. A firm dark decay commences at the apex of the fruit surrounding the dead floral parts. This rot extends back slowly for half-an-inch or so, causing the tissue to shrink and become more or less rounded in contrast to the angular nature of the immature fruit. There is a sharp line of demarcation between healthy and diseased tissue. Usually no further extension takes place, but the fruit ripens prematurely. The disease is caused by a fungus (*Stachylidium theobromae*). The spores of this organism are produced in abundance on the surface of the blackened area, where they form an ashy grey or pinkish-grey coat. In typical cases this gives to the shrunken end a striking resemblance to a burnt cigar tip, hence the name. The old shrivelled floral organs often persist for considerably longer than normally on affected fruit.

Although occasionally a large proportion of the fruit in a bunch is affected, it is more common for only a few fingers to show the disease; hence special control measures are not usually required. However, it is a wise precaution to open up the young bunch, where necessary, to the light and air and to remove the bracts which tend to remain attached to the developing hand, especially during wet weather. After a spell of dry weather when choke throat is in evidence, splitting the top of the pseudostem may be necessary to relieve the pressure on the out-coming bunch and so avoid injury to the tips of the fingers.

BLACK FINGER

While the bunch is still young and the fruit immature and angular one or more fingers may develop a jet black decay commencing at the tip and extending back towards the base until, unlike cigar end, the whole of the fruit becomes tapered by the gradual shrinkage of the affected region, which remains firm and eventually dries up to form a mummy. In the later stages numerous minute raised pustules constituting the fruiting bodies of the casual organism appear over the surface.

The cause of black finger has only recently been investigated. A fungus (*Phoma* sp.) has been isolated from affected fruit, and its pathogenicity proved by artificially inoculating healthy fruit on the plant and in the laboratory.

So far this disease has not appeared with sufficient frequency to call for special control measures, but the ventilating of the young bunch as for cigar end should help to prevent its occurrence.

GUMMING

Fruit which have developed gumming can be readily distinguished as the bunch begins to fill out, by a tapered or pinched appearance of the flower end. One or more fruit so affected may be scattered through the bunch. On splitting the fruit lengthwise a reddish-brown gummy condition of the tissues below the flower tip and extending along the centre will be apparent. Dark gummy specks of less intensity may form a more or less interrupted band along the outer margin of the pulp. Affected fruit does not ripen as soon as the normal, the tip in particular remaining green.

A disease occurring in the West Indies which closely resembles this one has been shown to be due to infection by a bacterium through the floral organs of the young fruit. As bacteria have in the past been isolated from Queensland specimens, it is possible that the same trouble exists in both countries.

So far it has not been necessary to take special precautions for the control of this disease, though the remarks already made regarding the opening up of the young bunch and the removal of bracts can be applied here also. All fruit having the characteristic pinched tip should of course, be rejected when packing.

BLACK PIT

Black pit has made its appearance on frequent occasions since it was first recorded in 1930. Commencing as small reddish spots, shallow black pits of $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter are formed in the skin of green fruit. The spotting is most abundant on the upper hands of the bunch and on mature fruit.

The lesions are restricted to the skin and do not usually act as centres for any further decay. However, when the pits are numerous the disfigurement is sufficiently serious to render the fruit unfit for market, and at times whole bunches have had to be discarded.

The cause of black pit is not definitely known, but it has been observed that bunches bagged in the manner advised in connection with leaf spot develop few or no spots. Accordingly this means of reducing loss is recommended in plantations subject to the disease.

SQUIRTER

Squirter is a disease rarely seen in Queensland, since it usually makes its appearance in cased bananas after arrival on the Southern markets.

A fruit typically affected with this disease has the pulp decomposed to a dark semi-fluid state so that a squeeze of the hand will expel it in a stream from the stalk end. At an earlier stage there will be found a dark area of rotting tissue lying along the centre of the fruit with or without an obvious connection with the finger stalk through which infection almost invariably occurs. External symptoms may take the form of a blackened stalk, but are often lacking altogether.

The disease is caused by a fungus (*Nigrospora sphaerica*), which for the most part exists in a non-parasitic manner on leaf bases, the bunch spathe or other dead banana material in the plantation, and on discarded bunch stalks an rotting fruit in the dumps near the packing shed. The shiny black fungus spores produced in these situations are liberated into the air and contaminate the fruit either in the plantation or during packing operations. The fungus then gains entrance through the broken fruit stalk and travelling down the vascular fibres sets up the typical rot in the pulp of the fruit.

Squirter does not develop when the fruit is in the unsprung or in the fully ripe condition, but in the intermediate stages. About ten days are necessary for the complete rot to take place. The disease is seasonal in its occurrence and is met with only in the cooler months from May until late spring. Chilling may have some indirect bearing on squirter development, and the delayed ripening period in the winter months may also be a factor in its seasonal distribution.

CONTROL

1. Plantation and packing-shed hygiene will help to reduce the number of spores present. The bunch spathe and loose trash should be removed from the vicinity of the bunch. Rejected fruit and bunch stalks should be buried or burnt and the packing shed sprayed out occasionally with a 5 per cent. solution of formalin.

2. During the winter months squirter-liable fruit should be marketed without delay and ripened as quickly as possible by up-to-date methods so that the period during which the rot can take place is reduced to a minimum.

3. Packing in part hands instead of singles will often reduce the number of fruit infected.

4. Bagging bunches during the winter months, as has been advocated for leaf spot control, may help with squirter also, as it will lessen the amount of chilling likely to take place.

FRUIT STALK ROT OR BLACK END

This is purely a transport and market trouble. As the fruit ripens a soft, black, and usually wet rot commences at the broken end of the fruit stalk, or, in the case of bunch fruit, in wounds caused by bending the fruit at its point of attachment to the main stem. This results in a black shrivelled condition of the fruit stalk, from whence the rot may extend to the adjacent skin of the fruit and produce a soft watery condition of the pulp beneath.

Various wound parasites, more especially *Glaeosporium musarum*, *Nigrospora sphaerica*, *Pusarium* spp., and *Stachylidium theobromae* are associated with this type of decay. The development of *G. musarum* is favoured by high temperatures and most of the black end in summer is due to this organism. *N. sphaerica* is active during the winter and supplements the work of *Glaeosporium* at this time. The species of *Fusarium* and *S. theobromae* are of comparatively minor importance and are apparently unrestricted as regards their time of appearance. All these fungi occur abundantly on banana refuse in and around the packing shed and on dead leaf stalks, bunch tracts, and other parts of the plant in the field. Consequently contamination with the spores of these organisms is easily accounted for. Bruises caused by rough handling and the surfaces exposed by breaking the bunch into fingers then serve as points of entry of the fungus which develops further during transport.

CONTROL

1. Practise packing shed and plantation hygiene as recommended for squirter control. The plants should be kept reasonably free from dead leaves by periodic trashing.

2. Cut, pack, and rail fruit with the minimum of delay.

3. During periods when black end is prevalent the consignments should be ripened immediately they arrive at the market by up-to-date methods, keeping the humidity as low as practicable during the process, and the temperature at the correct point.

4. Pack in part hands rather than singles, avoiding undue tearing when splitting up the hands.

5. In the case of fruit sold and ripened in the bunch practically all loss may be eliminated by careful handling of the fruit so as to avoid bruising fruit stalk.

ANTHRACNOSE

Like black end, anthracnose is mainly a marketing trouble. Dark slightly sunken areas appear on the skin of the ripening fruit and enlarge rapidly. At first the skin only is affected, but later a soft water-soaked condition extends into the pulp and greatly hastens what is commonly known as the over-ripe condition. Under moist conditions the surface of the spots becomes covered with a pinkish mass of the spores of *Glaeosporium musarum*, the fungus causing the disease.

Anthracnose is of most importance during a period of two or three months in midsummer. The skin of the fruit marketed at this time appears to be of a softer nature and more susceptible to attack, and the high temperatures prevailing favour the growth of the parasite. At this time black depressed areas may be formed on green fruit in the plantation, but this is of rare occurrence.

No definite means of control are known. The recommendations made in connection with black end are applicable here also. Careful handling at all stages to avoid bruising is important. As there is a tendency for fruit to ripen quickly during the summer months when anthracnose is prevalent the correct picking maturity must be studied in order to avoid the waste associated with fruit arriving in a mixed ripe condition. Fruit should not be allowed to stand in the hot sun either before or after packing.

TREATMENT AND CARE OF TREE WOUNDS*

NEGLECTED WOUNDS

WOUNDS of all sorts are so common on trees that most people have become oblivious of the damage arising from neglected wounds, or at least they underrate the possibilities of damage. Every broken limb and every other kind of external wound that penetrates to the inner bark may allow active plant or animal parasites or rot-producing organisms to enter unless these injuries receive prompt and proper treatment and care.

The best, safest and most economical means of preventing future extensive decay, disfigurement, or premature death of a tree is to attend to each wound as soon as it occurs. This kind of work is simple and comparatively inexpensive. If a wound is allowed to remain untreated for some years (as commonly happens) decay-producing organisms almost invariably enter and produce a rotted area in the wood beneath, often so extensive that a violent wind may break the tree at the decayed and weakened spot. Roadside trees weakened by decay are especially dangerous to traffic. Uninjured bark or prompt and proper treatment of an injured area usually prevents the entrance of organisms causing decay.

If an untreated wound of several years' standing has developed a considerable area of decayed wood or bark, the first question to be considered is whether the tree or limb involved is of sufficient value to warrant the expense of properly treating it. Should it be decided to undertake the work, the too common mistake of neglecting portions that are difficult to reach should not be made. Under ordinary conditions it should be a thorough, complete, and sanitary job, or else nothing whatever should be attempted. If a tree is badly decayed or injured, it may be better to remove it and set a healthy one in its place; or it may be braced or guyed to prevent breakage in a violent storm; or the decayed matter may be removed and the cavity treated in accordance with directions given in this bulletin. When large areas of rotted wood have been excavated and the cavities either filled or left open, the wounds will rarely heal completely. Careful and thorough cavity work on the trunk of a tree is of much greater importance than on a limb, primarily because the limb often may be cut off later well behind the diseased area, if need be, without materially impairing the general health of the tree.

Many people still fail to realize the full extent to which properly located, healthy, and well-kept trees enhance the value of real estate, particularly for residential purposes. From this point of view alone, it is wise to keep

* By J. Franklin Collins, formerly Senior Pathologist, Division of Forest Pathology, Bureau of Plant Industry. Extracted from U S. Department of Agriculture Farmers' Bulletin No. 1726 of August, 1934.

trees in a healthy and vigorous condition. Oftentimes historical association, scientific value, economic importance, or rarity of the species outweighs all other considerations. For various reasons trees are unquestionably a real asset whether on private, semiprivate, or public property, including highways and byways.

It costs comparatively little to treat recent wounds properly. Such treatment contributes greatly to the health, beauty, usefulness, and value of the trees in years to come. This is one of the great economic lessons connected with the care and treatment of trees.

Occasionally, in this country, but more frequently in Europe, an old or irregular cavity is regarded as more ornamental and picturesque if left untreated. Undoubtedly the inrolling callus in such cavities contributes very materially to the strength of the trunk, in much the same manner that H-and I-beams strengthen a building or a bridge. It is usually advisable to reduce the size of the crown when a trunk is much weakened by decay, whether or not the decayed matter is removed and the cavity filled. This is done by cutting off a considerable portion of all the main limbs, which produces a more compact crown and lessens the strain on the weakened trunk.

PREVENTION BETTER THAN CURE

Preventing the formation of a pocket of decay or preventing a disease from getting started on a tree is far better and much more economical than trying to cure either in later years.

If trees are located along driveways or streets, or in other situations where horses can easily reach them, they should be protected by tree guards. If a limb is so located that it crowds or rubs another, one of them usually should be removed. Cut out the one that is least essential to the tree, from whatever standpoint is considered most important, such as size, vigor, location, symmetry, etc.

Although the remaining pages of this bulletin are concerned mainly with pruning and cavity work, the significant fact should always be borne in mind that proper feeding and watering of diseased, decayed, or otherwise weakened trees often are of much greater importance. It usually is an excellent rule to feed all trees that have been subjected to much pruning or cavity work, in order to stimulate prompt callus formation over the edges of all wounds, and it is quite essential to do so in the case of weakened trees.

If injuries remain untreated, decay may penetrate into the interior of the tree and increase from year to year until large limbs, or the trunk itself, become so weakened that they break in a violent wind. It requires comparatively little time and money to clean and paint a freshly made injury. It often requires much time and money to treat properly the same injury after it has been neglected for a few years. Moreover, an injury promptly treated will heal and cover the scar more quickly and effectively. Almost every large decayed area has resulted from an injury that would have required comparatively little time and effort to clean, sterilize, and dress at the time it occurred. The most economical and effective method of preventing a decayed area in a tree is to attend to the injury that

may eventually give rise to it as soon as the injury occurs, perhaps 20 or 30 years before it would become a real menace to the tree. This fact should be remembered by tree owners and persons charged with the care of trees. If acted upon, it may mean an ultimate saving in later years of many hundred per cent. in the cost of keeping the trees in good condition.

Practically all cavities might have been prevented if the original injury had been properly treated as soon as it occurred, so that the healing tissues could have grown over the sterilized and protected wound. Because this has not been done to any extent in the past, a demand has been created for tree-surgery methods—methods which often cost today, through past neglect, many times the amount that it would have cost to forestall the decay 10 or 20 years earlier. Moreover, an injury promptly treated might today be entirely or relatively inconspicuous. Neglect for 10 or more years means that the decayed area will be conspicuous and unsightly for years to come, if not during the entire remaining life of the tree.

WHAT TREES ARE WORTH TREATING

Most shade and ornamental trees with only a few dead limbs are unquestionably worth attention. Others that have many dead limbs or decayed areas may not be worth the expense, particularly if they are rapid-growing short-lived trees. This point should be considered very carefully before any work is undertaken. Under no circumstances should a badly diseased or insect-infested tree be allowed to remain as a menace to nearby trees that are in a more healthy or entirely healthy condition. All diseased or insect-infested bark, wood, or leaves should be removed and all freshly cut surfaces properly treated, or the entire tree should be removed. In most cases the diseased portions should be burned immediately; in case of doubt as to the contagious character of the diseased portions, it is better to err on the safe side and burn them. No one can decide better than the owner whether a tree is worth the expense of trying to save it, because the actual commercial value of an ornamental or shade tree usually has nothing to do with the decision. It is generally a question of esthetic value, or historic associations, or rarity of species, or location for shade. A man who has had experience in caring for mutilated or diseased trees may be able to say definitely whether it is possible to prolong the life of the tree, but the owner, who has to do the work or pay the bill, is the one who will have to decide whether the tree is worth the expense of treatment. Often the owner will be better satisfied in the end to have a badly diseased or mutilated tree replaced by a healthy, perfect one. In expert hands the moving of comparatively large trees is no longer a hazardous undertaking, although it may be expensive.

TREATMENT

By far the most important operation is to treat all injuries as soon as possible. All splintered or loose wood and bark should be removed with a sharp cutting instrument and the cut edges shellacked, and, a day or two later, the whole wound properly dressed, as described below.

When a wound has developed an area of decay, all of this should be removed and the cavity treated the same as any freshly made wound.

If decay has progressed for some years it may be impossible to remove all of the fungus causing it without so weakening the tree that it will be a menace to life and property. This is one of the penalties of not attending to injuries as soon as they occur. If all the decayed tissues are not removed the fungus may continue its work of destruction.

In treating tree wounds a few fundamental principles must be observed, in order to secure permanently good results. These may be summarized briefly as follows:

(1) Remove all decayed, diseased, or injured wood or bark. When it is on a limb this can often be done best by removing the entire limb; if it is on a large limb or on the trunk it may be necessary to cut out the decayed matter, leaving a cavity.

(2) Sterilize all cut surfaces. This may be omitted if a good sterilizing dressing is used.

(3) Protect all cut surfaces from external moisture and other injurious external agencies by also applying a more permanent dressing over the sterilized surface.

(4) Leave the work in the most favorable condition for rapid healing; this may sometimes necessitate filling deep cavities.

(5) Watch the work from year to year for defects, and if any appear, repair them immediately.

The simplest type of work consists in removing dead or dying limbs or neglected or decayed stubs and in treating the wounds so as to prevent the entrance of decay-producing organisms and moisture while the healing is taking place. A more complicated type consists in digging out decayed and diseased wood and treating the freshly cut surfaces of the cavities, and sometimes in filling the cavities with suitable material. The artificial filling of an ordinary cavity does not usually increase the strength of the trunk or limb. An improperly filled cavity is probably always a menace to a tree.

SOME THINGS TO BE AVOIDED

The careless use of a long pruning hook or other implement to break off small dead twigs should be avoided, as every bruise may become the point of entrance of disease or decay. Climbing spurs produce wounds that are very easily and frequently infected. Spurs should never be used except on a tree that is soon to be removed or destroyed. A man who insists on using climbing spurs in tree-repair work should never be allowed to work on trees. Nails and hard leather soles and heals on shoes often cause injury. Rubber-soled tennis shoes, or "sneakers", or some similar soft-soled shoes that will not slip should be worn when it becomes necessary to climb a tree.

Limbs or trees should never be guyed by passing wires, chains, or ropes tightly around them. These may eventually strangle the portions above the encircling band. Encircling fence wires, telegraph wires, or clotheslines may act in the same way, killing all parts of the tree beyond the ligature if they remain tightly drawn around the limb or trunk for any great length of time, often in less than a year.

JOHNE'S DISEASE OF CATTLE*

JOHNE'S disease is a malady particularly affecting cattle with lowered resistance, irrespective of breed. It is a chronic infectious disease, and it can only occur as the result of a pre-existing case. Bad management and care, improper feeding and overproduction will seriously lower the resisting powers of an animal, but cannot produce this disease. It is necessary for the specific microbes to gain entrance into the body of the animal before Johne's disease can develop.

Health, disease, or death, from a technical viewpoint, is in reality the result of a struggle for victory between the resisting forces inherent in the individual body and the disease-producing germs which invade it.

When an animal, maintained under conditions which lower its resisting powers to disease, comes in contact with this infection, the germs are able to multiply in its body and to increase their activities to such an extent that the normal functions of the tissues in which they are located are deranged and disease results. When, however, the germs gain entrance to the body of an animal with high resisting powers they are destroyed by the body cells and disease cannot then develop.

This particular microbe is an organism of very low virulence and the disease which it produces progresses very slowly and develops in a very insidious manner. Months and years may pass before the animal shows noticeable signs of illness.

SYMPTOMS

Infection may occur during calfhood, but symptoms have not been observed in animals under eighteen months of age, and rarely before they are two years old. Symptoms are usually first observed after calving, at a time when the animal's resisting powers are at a low ebb. They are more frequently seen in animals ranging from two and a half to six years of age, and occasionally in older animals.

The characteristic symptom of this disease is a diarrhoea, and until it occurs little change can be detected in the appearance and behaviour of the animal.

The attacks of diarrhoea occur periodically and become more frequent and of longer duration as the disease progresses. The animal begins to lose flesh more rapidly and there is soon a marked reduction in the milk secretion of lactating cows. The appetite as a rule remains relatively good.

It is a painless disease until the last stages are reached, when the animal, reduced to a mere skeleton, may show evidence of discomfort and suffering.

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* By George Hilton, V.S., H.A.R.C.V.S., Veterinary Director General, Health of Animals Branch. Extracted from the Dominion of Canada — Department of Agriculture, Bulletin No. 167 — New Series, 1934.

The periodic attacks of diarrhoea generally observed until death occurs and the extraordinary loss of flesh during the later stages of the disease, are typical of this infection.

The periodically appearing, but persistent diarrhoea of Johne's disease, with its mash-like watery fæces, which soil the hindquarters as well as the floor and walls of the stalls, should at once create suspicion. It should not be confused with the haemorrhagic diarrhoea of young calves caused by a minute animal parasite producing coccidiosis, nor with the diarrhoea affecting young cattle from calfhood, caused by stomach worms (Parasitic Gastritis).

POST-MORTEM APPEARANCES

Many diseases do not produce significant changes in the body which can be recognized at post-mortem by individuals who have not studied the body in health and disease. Johne's disease, however, generally produces marked changes along the lining of the small intestines (bowels). This surface presents a corrugated appearance similar to the corrugated zinc surface of a washboard, except that the corrugated lines are not as uniform. The walls of the intestines are much thickened and the intestinal lymphatic glands are swollen.

It has also been observed that the fat in the carcass of an affected animal is of a marked yellow colour.

It is remarkable that this chronic fatal disease does not cause other visible changes in the body, although it is not a difficult one to recognize after symptoms develop, nor to confirm for all practical purposes after death takes place.

METHODS OF INFECTION

The germs producing this disease generally gain entrance into the body with feed and water which have been contaminated or polluted with the discharges from affected animals.

Animals may become infected by direct contact with an infected animal, and by contact with infected premises or anything that has been soiled by the discharges of infected animals through the act of licking. They may also become infected by grazing on pastures on which infected animals have grazed.

While it has not been definitely determined how long the germs of this disease can live outside of the animal body, it is not considered safe to place animals on pastures which have been contaminated until the pastures have been vacant for a period of at least two months.

Contaminated ponds and pools are particularly dangerous and should be permanently excluded as a source of water supply.

Manure piles are also particularly dangerous, and the practice of leaving manure where animals can come in contact with it cannot be too strongly condemned. It is a certain means of spreading this infection through a herd; is often responsible for the spread of other diseases and for the infestation of the animals with parasites or worms. It is consequently important, and it pays under any circumstances to store manure at all times where animals cannot have access to it.

HOW THE DISEASE SPREADS

The infected animal is the original source of infection and it will infect those that come in contact with it.

The movement of infected animals by any means for any purposes anywhere leaves a train of infection.

The discharges, and particularly the fæces in this disease, and anything that may be contaminated with these discharges, including the hands, clothes and boots of attendants and others, may carry the infection.

Dogs, cats, and other smaller animals coming in contact with these discharges may spread the infection to many premises.

PREVENTIVE MEASURES

It cannot be stated too emphatically, nor repeated too frequently, that Johne's disease is a malady affecting cattle with low resisting powers and that the chief preventive measures consist in the maintenance of cattle in the highest possible state of vigour.

Caution should also be exercised in the selection of animals for addition to herds, and it is good sound practice to isolate them for at least thirty days before putting them with the herd.

As there is reason to believe natural infection frequently takes place in the early days of life by contact with infected dams or surroundings, calves should be removed immediately after birth from the contaminated place and raised where they will not be subject to exposure to infection.

With a better knowledge of disease brought about by scientific research, diseases causing enormous losses in the past have been eliminated over vast territories and brought under better control elsewhere.

While the incidence of certain serious diseases has changed under modern conditions, other diseases are slowly but surely increasing and are spreading and invading new territory.

SANITATION

Animals kept in badly ventilated dirty stables, lose their vigour, and when exposed to infection easily contract disease. Dark, dirty, crowded and ill-ventilated stables, are especially favourable to the propagation of disease, and when infection is introduced into such premises disease not infrequently spreads with startling rapidity.

Good ventilation must provide for two things, first, the removal of foul air from the inside, and, second, the bringing in of fresh air from outside the building. No system is good that fails to accomplish these objects without causing unnecessary draughts. When both inlets and outlets are proportioned to the size of the building there should be a constant circulation of air, and no sensation of closeness should be perceptible in the stable.

Stables should be cleaned out often and the manure should be stored in a locality where animals cannot gain access to it. Cleanliness includes keeping the walls and ceilings free from dirt, dust and cobwebs. These are all good resting places for disease germs.

Whitewashing the interior of the stable at least twice a year is a great aid to cleanliness, and also has a destructive action upon disease germs.

THE FACTORS AFFECTING EROSION*

THE two agents causing erosion are wind and moving water. Although wind erosion can, under certain conditions, cause very severe erosion, it is not intended to discuss wind erosion specifically; the application of some of the principles of soil conservation discussed below will effectively prevent erosion by wind. Erosion by water can be controlled if the causes of its accumulation and the laws governing its flow are appreciated.

Water enters the soil not over the whole surface but by means of the spaces or pores between the particles. The smaller the spaces the slower will be the rate of absorption. Thus, a soil which has been broken down to dust will have very fine pores and absorb water slowly, while a soil in which the ultimate soil particles are cemented together in the form of crumbs, will have large pores and absorb water readily. The run-off, under similar conditions of rainfall, will be less on the latter type of soil than on the former. This is also the explanation of the fact that soil is more liable to erode after long continued cultivation than when first broken from the virgin state. The virgin soil contains an adequate supply of humus to cement the soil particles into crumbs.

The run-off too is greater from a bare soil than from one carrying a vegetal cover. Rain beating on bare soil compacts it, the surface soil is broken up into a thin mud which, passing into the soil pores, clogs them, making them smaller and reducing the rate of absorption. The mitigation of the impact by vegetation helps to prevent the beating of the soil into mud and thus clear water, or water carrying very little in suspension, is absorbed by the soil pores. The litter collecting below a vegetal cover, too, acts as a shock absorber but there are further effects. It has a definite filtering and flocculating effect, clearing any muddy water that may accumulate, permitting clean water only to reach the soil. Lowdermilk has demonstrated the marked effect of a forest litter in maintaining the absorptive capacity of a soil for water. On a fine grained soil covered with forest litter the total run-off, from a rainfall of 200 inches, was only 0·7 per cent. from the same soil, on which the litter had been burned, under otherwise identical conditions the run-off was 38·7 per cent. of the rainfall.

There is yet another effect observed so far on the volcanic red soils only. Under certain types of vegetation, especially under those that produce a heavy litter, there is a marked puffing up of the soil to form a loose tilth of soil crumbs capable of absorbing water rapidly. The same phenomenon is observed under a grass mulch. The importance of this phenomenon lies in the increase in the capacity of soils that have developed such a structure to absorb water.

* By V. A. Beckley, M.C., M.A., A.I.C., Senior Agricultural Chemist. Extracted from Bulletin No. 1, of 1935, of the Colony and Protectorate of Kenya Department of Agriculture.

Under a grass cover there is protection of the surface soil but the litter produced is not as efficient as that of forest or mixed bush. The puffed structure does not develop to any marked extent so that there is quite a large run-off under heavy rain.

As soon as there is more water than the soil can absorb it begins to run off and, once moving, it is capable of doing work, the amount depending upon the square of its velocity. Thus a stream of water moving at a speed of two miles an hour can do four times as much work as one moving at one mile an hour. Its carrying capacity, or its erosive capacity, varies as the fifth power of the velocity. In the two streams postulated above, the one has thirty-two times the erosive capacity of the other. The size of particles carried varies with the sixth power of the velocity. Thus, in the two streams, the one will carry particles sixty-four times as large as the other. Not only does velocity affect carrying capacity but so does the amount of silt carried. A heavy silt-charged stream will transport larger masses than its velocity alone would permit. Considering these laws of hydraulics the power of moving water to erode soil is evident.

The factors governing velocity of run-off are slope, nature of surface and volume of water. Other things being equal, an increase in slope of four times doubles the velocity of run-off, that is, if a velocity of one mile an hour is developed on a slope of 1 in 100, a velocity of two miles an hour would be developed on a slope of 1 in 25. The effect of the nature of surface is rather complicated but probably, if it be considered a matter of friction between the water and the surface, a picture of the effect will be gained. On a dead smooth sloping surface there is little friction and water runs off rapidly. If the surface be slightly roughened, analogous to a rolled field, the flow will be retarded by the increased friction; further roughening slows down the flow again, analogous to water flowing off a ploughed field if constant obstacles are interposed as on a grassy slope the flow becomes very slow indeed. But if, at the same time, the volume of water is considerably increased, the water can over-ride the obstacles and maintain a high speed.

In nature the matter is very much more complicated. Water does not flow down a natural surface in a smooth sheet but tends to collect in natural depressions. Perhaps the discussion of an actual case will illustrate the effect better. Visualize a bare sloping field, having the mild slope of one in a hundred under a storm of rain. Water unabsorbed begins to run down the slope. Inequalities in the surface concentrate the water into depressions to form little streams, which become larger as they proceed down the slope. Under quite ordinary conditions the streams at the top of the slope would be half-an-inch deep and three inches wide. As they proceed down the slope they would become deeper and wider (though under certain conditions discussed in the next paragraph, they would remain about the same width). Assume this to be the case here and that midway down the slope the depth has become three inches and at the bottom of the slope it has reached six inches. The velocities of the streams at the three points, according to the laws of hydraulics, would be 0·86, 1·82, and 2·40 feet per second. The erosive powers at the three points

would be in the proportions of 1, 43 and 170. At the top of the slope the run-off can do little damage, at the bottom the increased flow can and does eat into the soil very rapidly. Normally the streams do widen as they become deeper, leading to the development of lesser velocities than those calculated but velocities sufficiently great to do much damage.

The nature of the treatment received by the soil considerably affects the character of the run-off. Very often in cultivating a field the line of least resistance is taken, and implements are run up and down the slope. The traffic of the tools tends to produce small channels to carry off unabsorbed water, while the ridges of compact soil, left below the surface, tend to confine the width of the streams, making them deeper and faster than would otherwise be the case. The condition is that described in the preceding paragraph. If cultivation is across the slope there would be no downward channels to carry off unabsorbed water. With cultivation along contour lines one has a series of parallel channels and, when they fill, a wide stream of low velocity would be produced. It is, however, difficult to plough along contour lines and thus there is always some lowest point towards which water would flow, thus tending to produce one or more large flows. Here the damage would be marked but would immediately call attention to itself and means could be employed to regulate the damage.

The character of the crop, too, affects the nature of the surface over which the unabsorbed moisture must flow. A widely-spaced crop like maize does not interfere much with the flow of water nor does it offer much protection, in its early stages, to the direct beating of rain. Wheat, being closer-spaced, offers more resistance both to run-off and to beating, while a matted crop, like peas grown as a cover crop, offers more resistance still. The distribution of the roots of the crop too affects the intensity of erosion. It is evident that the close packed roots of a crop of wheat will offer more resistance to erosion than the sparse roots of a maize crop.

Soil, lacking in cohesion, if underlain by a more compact layer, is liable to become supersaturated and suspended in the water when the whole mass is likely to slip bodily down the slope. A similar effect happens to the non-coherent soil between the ridges on a slope cultivated up and down the slope.

In this connection the direct abrasive effect of the material in suspension must not be overlooked. The large amount of silt derived from a non-coherent soil gives moving water an enhanced power to tear soil particles away from the main mass.

The structure of the soil, too, affects the rate of erosion. Not only does a well-developed crumb structure mean a good capacity to absorb water but also the crumbs themselves, being compound particles, are heavy, requiring a fair velocity of run-off to move them. When the crumb structure has been broken by bad cultivation the fine particles produced are very readily transported, and such soils erode readily. The property is associated with the nature of the clay in these soils. Unlike the clay

of the black cotton soils, it does not swell much on wetting nor does it become sticky. The crumbs developed do not break down on wetting and continue to provide an absorptive surface. The small tendency to swell also means that the soil pores, down which water percolates to the sub-soil, do not have their effective diameter much reduced. The black cotton soils, although they do develop a good crumb structure under cultivation when dry, lose this on wetting. They are receptive of early rains but soon lose their absorptive surface. The marked swelling reduces the size of the pores, down which water percolates, and very soon these soils cease to absorb rain at all, developing heavy run-off capable of causing severe erosion.

The structure of the sub-soil also affects the rate of erosion. In the red soils the sub-soil is coherent, drying into flat plates of a fair size Water readily percolates through the cracks which close up slowly on wetting. When the sub-soil has been exposed by erosion the coherent nature of the sub-soil and the heavy blocks prevent any further erosion except at a very slow rate indeed. The black cotton soils dry into a very marked granular structure, very absorptive of water when dry. Once the soil has been exposed and gully erosion starts, the granular structure of the sub-soil permits of very rapid erosion, the individual granular masses break away from the general mass very easily and soon are reduced to fine silt by moving water.

An obstacle in the flow of a stream of water causing a miniature waterfall may, on certain soils, have a very marked effect. The writer once observed a cattle tract converted into a donga three feet deep in the course of a single afternoon. The main cause was a stone lying in the track. Water, running away down the track, falling over the stone, had its velocity appreciably increased immediately below the stone. This enabled it to cut away the coherent surface layer, exposing the non-coherent granular soil below. The increased fall further speeded up the flow, augmenting the erosive capacity, and in a very little while a hole developed. The direct abrasive effect of the suspended silt now began to have an effect, cutting away the lower lip of the hole. Accumulating effects soon produced a gully which then proceeded to cut its way backwards into the soil.

Erosion by water is a cumulative process, not only in the manner described above, but in the general effects. The absorptive surface is destroyed by beating, water runs off carrying away the humus-containing surface soil. The soil is now less absorptive of water, run-off increases carrying away more soil; the clogging of the pores further increases run-off. Each increase of run-off means an increase in velocity and an increase in erosion. Therefore, when a case of erosion is being reviewed all the factors and their interaction upon each other must be considered.

REVIEW

"The Diseases of the Banana and of the Manila Hemp Plant", *by G. W. Wardlaw. Macmillan & Co., Ltd., London.* 30s.

THE progressive agriculturist, the student and the research worker are often severely handicapped by the fact that information regarding the diseases of tropical crops is scattered through agricultural and mycological literature from all over the world and that reference to papers is often difficult, if not impossible. Dr. Wardlaw has written a book in which relevant information has been collected and compiled in a form convenient for reference and study. That he is well qualified to do so is obvious from the fact that he has been working on problems connected with the pathology of bananas since 1928, his published work having borne the stamp of a careful and thorough investigator.

The book contains a wealth of information and it is interesting to note how large a proportion of our knowledge of certain diseases, especially of Banana Wilt (Panama disease) and of the storage rots of bananas, is due to the author. He has worked in the New World and his personal observations are confined to diseases which occur there. Diseases, such as Bunchy Top disease, of which he can have but little personal knowledge, are however fully described. There is every indication that a careful scrutiny of a mass of literature and an impartial summing-up of the relative values of observations have been made in the description of all diseases.

The book opens with a short introductory chapter in which banana cultivation is discussed, with particular reference to Central America where its cultivation on a commercial scale has been widely exploited. Following this, the book is divided into four main sections covering (a) soil-borne, vascular and stem diseases, (b) plantation diseases of fruit and leaf diseases, (c) virus diseases and (d) storage diseases.

A very full account of Banana Wilt (Panama disease) occupies the greater part of the first section. All aspects of the disease are discussed in detail and the whole forms an extremely able and lucid dissertation on the disease. The description of the work on the breeding of varieties of bananas resistant to the disease makes fascinating reading and the manner in which this very difficult and complicated problem has been faced inspires admiration. The section also contains descriptions of the Bonnygate disease, known only in Jamaica, bacterial vascular diseases and other miscellaneous root and rhizome diseases. It is perhaps worthy of note that the disease recently recorded in Ceylon, caused by *Fomes lamaoensis*, has not been found elsewhere.

The second section deals with the numerous diseases of fruits and leaves which occur on growing bananas and manila hemp plants. The

admirable illustrations will be of great assistance to those unacquainted with the diseases.

In the section on virus diseases there is a full description of Bunchy Top disease and of the measures for the control and eradication of the disease. Other less known virus diseases are also described.

On the storage rots of bananas the author writes with authority since a not inconsiderable proportion of the work that has been done on the prblems which arise in the collection and transport of fruit has been done by him. These problems do not arise to any extent in Ceylon since we have not developed an export trade in bananas.

The three appendices will be useful to students and research workers. The book contains a very full bibliography of 559 titles and it is obvious that the author has consulted most, if not all, of the references in the compilation of the book. A full index is provided.

The illustrations, many of which are original, are admirable. Their great number will be of considerable assistance to those who use the book and the reproduction is excellent. The author is to be congratulated on the production of this admirable text-book, which should find a place in the library of everyone who is connected with the cultivation of bananas or who is interested or engaged in problems connected with the diseases of bananas and manila hemp.

The book is well up to the high standard set by the publishers. It is expensive but well worth the money.—M.P.

MEETINGS, CONFERENCES, ETC.

TEA RESEARCH INSTITUTE OF CEYLON

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Friday, the 15th March, 1935, at 10-30 a.m.

Present.—Mr. James Forbes (Jnr.) (Chairman), the Hon'ble the Financial Secretary, Col. T. G. Jayewardene, V.D., M.S.C., Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. I. L. Cameron, R. G. Coombe, R. P. Gaddum, C. E. Hawes, J. D. Hoare, D. H. Kotalawala, M.S.C., A. W. L. Turner (Secretary), S. C. Bisset (Accountant) and by invitation Dr. Roland V. Norris (Director, T.R.I.) and Mr. J. W. Ferguson (Visiting Agent).

Absent.—The Director of Agriculture and Mr. D. T. Richards.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 11th December, 1934, were confirmed.

3. BOARD OF THE T. R. I.

The Chairman extended a welcome to Mr. R. P. Gaddum, the new Chairman of the Planters' Association of Ceylon, and Major J. W. Oldfield, who had returned from furlough.

Mr. B. M. Selwyn, the late Chairman of the Planters' Association of Ceylon was thanked for his services whilst a member of the Board.

The Chairman also pointed out that this would be Mr. Hawes' last meeting before he went on leave, and thanked him for his valued services whilst he had been Chairman of the Ceylon Estates Proprietary Association.

Announced that the following members had been nominated for a further period of three years as from the 1st January, 1935:—

Mr. R. G. Coombe representing the Planters' Association of Ceylon.

Major J. W. Oldfield representing the Ceylon Estates Proprietary Association.

Mr. D. H. Kotalawala, M.S.C., representing the Small-holders (nominated by H. E. the Governor).

(a) *Acting Chairman.*—The Board approved of the nomination of Mr. R. G. Coombe as Acting Chairman during the absence of Mr. James Forbes (Jnr.) from the 3rd April to the 8th May, 1935, when Mr. James Forbes (Jnr.) will be in Java with the Director.

(b) *Finance Sub-Committee.*—Major J. W. Oldfield resumed his seat on the Finance Sub-Committee *vice* Mr. J. C. Kelly, who had been acting for him.

(c) *Medical Sub-Committee.*—Major J. W. Oldfield was appointed to this Sub-Committee *vice* Mr. J. C. Kelly resigned.

4. FINANCE

Audited Accounts.—The Chairman informed the members that the Audited Accounts and Report for 1934 and the Statement of Accounts for January, 1935, had been discussed at the Finance Sub-Committee Meeting held that morning.

The Audited Accounts for 1934 and the Statement of Accounts for January, 1935, were approved.

5. SENIOR STAFF T. R. I.

(a) *Entomologist—Mr. C. B. R. King.*—Announced that this officer had resumed his duties on the 28th January, 1935.

(b) *Plant Physiologist—Mr. F. R. Tubbs.*—The Director informed the meeting that Mr. Tubbs had given a very successful lecture to the members of the Ceylon Association in London dealing with the work of his section.

Mr. Hoare asked if copies of Mr. Tubbs' lecture were available.

The Chairman replied that copies of the lecture would be published in *The Tea Quarterly.*

6. ST. COOMBS ESTATE

(a) *Superintendent.*—The Chairman announced that Mr. John A. Rogers had returned from furlough on the 18th January, and had resumed duties on that date relieving Mr. E. J. K. Garthwaite, who had been acting for him.

(b) *Visiting Agent's Report.*—There were no comments on the report of the Visiting Agent, a copy of which had been sent to each member of the Board under cover of Circular No. A. 1/35, dated the 21st January, 1935.

The Chairman informed the Board that that would be the last meeting at which Mr. Ferguson would be present prior to his departure on leave on the 3rd April. A vote of thanks to Mr. Ferguson was recorded for his services in visiting the Estate and for his willingness to give advice.

(c) *Acting Visiting Agent.*—Announced that during Mr. Ferguson's absence on leave, Mr. J. E. B. Baillie-Hamilton had agreed to act.

(d) *Estate School.*—This subject had been discussed at the last meeting and the Superintendent had now advised the Chairman that the school had been inspected. It was hoped that the school would be registered shortly.

7. EXPERIMENTAL SUB-COMMITTEE

A copy of the minutes of the last meeting of the Experimental Sub-Committee had been sent to each member of the Board on the 7th March.

8. WATER AND ELECTRICITY TO CADDY ON ST. COOMBS

The Board approved of the installation of electric light and water to the caddy at present leased to Mr. M. S. Salgado at Mr. Salgado's own expense.

9. SECRETARY'S LEAVE

The Chairman informed the Board that the Secretary, Mr. A. W. L. Turner was proceeding on leave as from the 20th March to the 20th November, 1935, and thanked Mr. Turner for the services he had rendered to the Institute and wished him *bon voyage*.

5. ANNUAL REPORT FOR 1934

The Secretary's portion of the Ninth Annual Report of the Institute had been sent to each member of the Board under cover of Circular No. A 3/35, dated the 2nd February.

11. T. R. I. CONFERENCE

The Chairman reported that the Fourth Conference of the Institute had been held on the 1st and 2nd March at St. Coombs.

The Meeting terminated with a vote of thanks to the Chair.

STANLEY C. BISSET,
Acting Secretary.

RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the twenty-fifth meeting of the Board of Management held in the Committee Room of the Chamber of Commerce, Colombo at 10 a.m. on Thursday, March 14, 1935.

Present.—Dr. W. Youngman (in the chair), Messrs. C. H. Collins, C.C.S. (Deputy Financial Secretary), I. L. Cameron, L. B. de Mel, J.P., U.P.M., C. E. A. Dias, J.P., George E. de Silva, M.S.C., F. H. Griffith, Col. T. G. Jayewardene, V.D., M.S.C., Messrs. J. L. Kotalawala, M.S.C., L. P. Gapp, the Hon'ble Mr. F. A. Obeyesekere, M.S.C., Messrs. C. A. Pereira, B. M. Selwyn, E. W. Whitelaw, Col. T. Y. Wright.

Mr. T. E. H. O'Brien, Director of Research, was also present by invitation.

1. MINUTES OF TWENTY-FOURTH MEETING

Draft minutes which had been circulated to members were confirmed and signed by the Chairman.

2. BOARD

(a) The Chairman reported the following changes in membership since the last meeting :—

1. Mr. J. L. Kotalawala, M.S.C., renominated to represent the State Council for a further period of three years, from January 22, 1935.
2. Mr. C. E. A. Dias, J.P., resumed his seat from February 2nd, 1935, relieving Mr. W. P. H. Dias, J.P., who had acted for him.
3. The Hon'ble Mr. E. C. Villiers, M.S.C., nominated to represent the State Council with effect from 4th March, 1935, in place of Mr. H. F. Parfitt, M.S.C., who had resigned.

(b) It was decided to invite the Director of Commercial Intelligence to be present at Board meetings when any item of special interest to him is to be discussed.

3. OFFICIAL OPENING OF BUILDINGS AT DARTONFIELD

(a) *Vote of Thanks to H. E. Sir R. E. Stubbs.*—Col. T. Y. Wright moved that the Board record a vote of thanks in its minute book to His Excellency Sir R. E. Stubbs for visiting Dartonfield and opening the buildings. The Hon'ble Mr. F. A. Obeyesekere seconded.—Carried.

(b) A supplementary vote to cover expenses incurred in connection with the opening ceremony, was approved.

A vote of thanks was passed to the Chairman and the Estate Committee for carrying out so satisfactorily the arrangements for the opening.

4. ACCOUNTS

(a) Items of expenditure in excess of estimates for 1934 were considered and approved.

(b) Statement of Accounts and Balance Sheet for 1934 together with the Auditor-General's Report, were adopted.

In the course of discussion on the financial position of the Research Scheme a suggestion was made that work on new uses for rubber should be extended. It was decided that the question should be further reviewed when experimental work at Dartonfield factory has been in progress for 6 months. It was reported that attention is being given to the possible local utilisation of scrap rubber and also to the production of cheap flooring material and waterproof fabrics.

(c) Rates of depreciation on buildings and equipment were revised in accordance with recommendations of the Deputy Financial Secretary.

(d) Nivitigalakele and Dartonfield accounts for November and December were tabled.

(e) The Chairman reported the renewal of fixed deposits totaliing Rs. 30,000/- and a new deposit of Rs. 30,000/-.

10. ANNUAL REPORT FOR 1934

The Chairman invited comments on the annual report which had been circulated to members. The report was adopted after discussion on the desirability of publishing early records of the yields of clones under test tapping.

6. OIDIUM LEAF DISEASE

A Committee consisting of Messrs. E. W. Whitelaw, R. K. S. Murray and T. E. H. O'Brien (Convener) was appointed to prepare a scheme for the control of oidium and report to the Board not later than June 1st.

7. STAFF

(a) A Selection Committee consisting of the Chairman, the Hon'ble Mr. F. A. Obeyesekere, M.S.C., and Mr. B. M. Selwyn, with the Director of Research in an advisory capacity, was appointed to consider applications for the post of Assistant Botanist and report to the Board at the next meeting. The Committee was also asked to report on the possibilities of training young Ceylonese Scientists for appointments in the Research Scheme.

(b) The Chairman reported that Mr. W. I. Pieris' present engagement would terminate on May 31st. It was decided to re-engage Mr. Peiris for a period of four years as Small-Holdings Officer. It was also decided that the officer should be sent to Malaya for a period of 6-8 weeks to study Small-holdings work there before taking up these duties in Ceylon.

DEPARTMENTAL NOTES

SOME NOTES ON SPRAYING AGAINST PLANT PESTS AND DISEASES

H. F. DAVIDSON,

MYCOLOGICAL DIVISION, DEPARTMENT OF AGRICULTURE

GENERAL

SPRAYING is one of the most important measures in controlling pests and diseases, especially in the orchard. In all progressive fruit-growing countries spraying is undertaken as a routine measure and is regarded as a valuable form of insurance. Spraying in Ceylon is in its infancy but there are indications that in the near future the more progressive growers will adopt this useful practice.

Spraying as a feature of disease control is well recognised. When satisfactory results are not obtained, the fault usually lies in the inefficient application of the spray. Accuracy as to time and method are essential for success, and of course the correct materials must be employed to deal with the particular pest or disease to be overcome.

Spraying is by no means easy or pleasant work. It must be done intelligently or the time and labour involved will be wasted. It is hoped that the hints given in these notes will indicate how some of the unpleasant features of the operation may be eliminated. In an undertaking that is neither easy nor pleasant, the adoption of expeditious and systematic methods enables the work to be accomplished in the minimum time and with the expense of the least possible energy.

Successful spraying involves first of all a knowledge of the pests and diseases to be overcome. The most effective remedies against these enemies and the proper time and method of using such remedies must be known. Those who do not know must take advice from those who do. A thorough attention to the smallest details is essential. When failure results it may often be attributed to the disregard of one or more of these important factors. Dry spraying or dusting will not be considered in these notes.

PRINCIPLES OF CONTROL BY SPRAYING

Plants are liable to attack by *insect pests* and *fungus diseases*, which for the purpose of these notes include diseases caused by bacteria, besides by other troubles which are outside the scope of the present subject.

From the present standpoint, *insects* may be considered in two principal classes.

1. Chewing insects or those that eat their food—*e.g.*, caterpillars, beetles, etc.

2. Sucking insects or those that derive their nourishment by sucking plant juices—*e.g.*, aphids, scale insects, etc.

Chewing insects can usually be controlled by the use of a 'stomach poison' such as lead arsenate which is sprayed on to the plants on which they feed. Sucking insects must be controlled by a 'contact insecticide' such as an oil emulsion or nicotine extract. Such insecticides must be brought into direct contact with the insect which is then killed, usually by suffocation.

Fungus diseases are caused by very low forms of plants which contain no green matter. *Parasitic fungi* can also be considered as falling into two large groups.

1. Fungi that exist on the surface of the plant.

2. Fungi that remain within the plant tissues and periodically produce spores or 'seeds' which appear on the surface of the host.

Fungi of the first group, of which *Oidium* is an example, are killed by the direct action of fungicides. Plants attacked by *Oidium* can therefore be actually cured by spraying. Fungi of the second group are much more difficult to deal with. A fungicidal spray can destroy only the spores which are produced on the surface but does not affect those parts of the fungus within the plant tissues. Spraying against such fungi must therefore be *protective* rather than *curative*. Spraying cannot bring back to life plant tissue which has already been killed by a parasite. If this fact is realised at the outset the objects and effects of spraying will be better understood and undue disappointment prevented.

The chief objects in spraying are to destroy fungi and insects present on the plant surface and to prevent healthy plants from being infected. These objects are attained in the first instance by the spray fluid coming into direct contact with the enemies; in the second instance by the spray forming a poisonous protective covering on the surface of the plants and either by killing fungus spores which come in contact with it or by poisoning insects which feed on the sprayed plants.

SPRAYING MACHINES

1. GENERAL

Years of experience have improved and evolved spraying machines which to-day are highly efficient and simple to operate.

To obtain the best results spraying machinery should be in perfect working order, otherwise disappointment and waste of time and labour will result. A spraying machine, like any other machine, will function efficiently and last in proportion to the care given to it. If it does not function properly the cause should be ascertained and the defect immediately remedied. With proper attention, a sprayer should last for several years.

Before choosing a spraying machine a number of factors has to be taken into consideration. Acreage to be sprayed, age and size of plants, frequency of applications, character of the land which has to be worked, labour and water supply are a few such considerations.

The types of spraying machines available vary from the small hand-atomizer of about 1 pint capacity to large motor operated power-sprayers which eject 10-20 gallons of spray per minute. The type of machine chosen should be suitable for each individual requirement.

Purchasing 'cheap' spraying equipment and materials is false economy; they will cost considerably more in the end. In purchasing any sprayer it is necessary to obtain also at least essential spare parts. If the sprayer is purchased through local agents they must be in a position to supply immediately any spare part.

2. TYPES OF SPRAYING MACHINES

These will be considered under two classes: machines that are suitable for the small or amateur grower, and those that are suitable for the professional orchardist. The small hand-atomizers, bucket-pumps and knapsack-sprayers fall within the first category. Barrel sprayers mounted on wheels, single or double-action hand and motor power sprayers are most suitable for the commercial orchardist.

(i) *Hand-Atomizer.*—The 'Flit' type of sprayer is a good example of the hand-atomizer. It is the smallest of the hand-sprayers and being light and convenient to handle is very useful in the small kitchen and flower garden; it is also suitable for *small* individual fruit trees.

Two types of these machines are available—continuous and direct action. The former is preferable as the nozzle and its feeder are detachable and facilitate cleaning. These parts are fixed in the direct action type. The continuous action type of hand sprayer costs about Rs. 2·25.

(ii) *Bucket-pump.*—This type of sprayer is composed of a bucket or some other container for the spray solution and a pump to which is attached a rubber hose terminating in a metal extension rod on to which is screwed a nozzle. Many bucket-pumps are supplied with an inadequate length of hose and it may be necessary to purchase an extra length of hose to allow of easy working.

Bucket-pump sprayers cost from Rs. 15/- to Rs. 150/- nett and are suitable for small gardens containing fair-sized herbaceous areas and for small groups of young orchard trees.

(iii) *Knapsack-sprayers.*—These machines are strapped on the back for operation. Two types of these sprayers are made. In the ordinary type the operation of pumping and spraying has to be done simultaneously so that both hands of the operator are engaged. This is very laborious work and is a great disadvantage.

A great improvement on the above type is the pneumatic knapsack-sprayer. The tank is filled with the spray solution and air pumped in and retained under pressure before spraying, thus saving much labour.

These sprayers are especially useful for working in the small orchard. For tall trees which cannot be reached with the standard equipment, bamboo-lance extensions are available.

Knapsack-sprayers cost from about Rs. 40/- for the ordinary type to about Rs. 120/- for the improved pneumatic models.

(iv) *Barrel-sprayers* mounted on wheels, operate on the same principle as the bucket-pump but have a greater capacity and are more powerful. They are useful on flat land and have a somewhat greater capacity for work than the pneumatic sprayers but involve greater labour to operate.

(v) *Power-sprayers* are either manually operated or motor operated. They consist essentially of a powerful single or double-cylinder pump mounted on a wooden base. Two or more leads of hose one of which is connected to the supply of spray solution, are attached to the pump. These machines cost from about Rs. 300/- and upwards and are very suitable for the commercial orchard.

The motor power-sprayer is much more powerful than the hand operated machine but is complicated, much heavier and costs considerably more. It is, however, eminently suited for the work it is intended to perform—*i.e.*, spraying very large and highly developed orchards. The hand power sprayer can work a fair acreage and for Ceylon conditions may take the place of the motor-sprayer when the latter cannot be afforded.

4. CARE OF SPRAYING MACHINES

Spraying machinery should be kept in perfect working order. One of the chief causes of breakdown is due to the machine not being thoroughly washed out with clean water immediately after use. *This point cannot be too strongly emphasised.* Sprayers should be washed out at least twice with clean water by operating them in the usual manner; sprayer tanks should be first filled with water and thoroughly shaken before doing so. After this all taps and joints should be lubricated with a drop of oil and all other metal parts wiped over with an oily rag. Makers' instructions with regard to the maintainence of machines should always be carried out.

Before starting out for the day's work, the machines should be tested to ensure that they are in perfect working order.

WASHERS

Faulty washers and loose joints are the most common cause of trouble in sprayers. These defects are easily remedied by replacing old washers as a routine measure with well greased new ones and by tightening up loose joints, if necessary, with a spanner.

Leather washers should always be used in preference to rubber washers which are unsatisfactory for Ceylon conditions. Spare washers should be well greased and always kept in stock.

NOZZLES

Most sprayers are supplied with at least two types of nozzles, each intended for a special purpose. The correct nozzle for spraying plants ejects the liquid in the form of a fine mist.

Blocking of nozzles is a common trouble and is often the result of inadequate straining of spray solutions and use of dirty vessels. Internal corrosion of metal parts due to inadequate washing also causes nozzle blockage.

Hoses are made of a rubber composition and are sometimes reinforced externally with a spiral of wire. Kinking the hose should be avoided as this would ultimately damage it and cause leakages. Spare hoses are a necessity.

Extension spray rods are usually made of brass and need little attention beyond thorough washing out after use and an occasional external cleaning. They should be light and not too long otherwise they become unwieldy. The stop-cock on the handle should be kept oiled for easy manipulation. Angle-bend extensions are a great advantage in spraying.

SPRAY MIXTURES

1. PREPARATION

Many ready-made fungicides and insecticides are available on the market. The use of reliable preparations will save much time and expense involved in the preparation of home-made materials which cannot always be relied on. It will always pay to get the best materials possible, though the claims made by the proprietors for each preparation cannot always be substantiated.

In preparing sprays the required quantities of materials should be measured *accurately*. To do this it is essential to have vessels holding known quantities. An apothecaries' measure (preferably enamelled) marked at least in ounces and a large vessel holding a definite quantity such as ½ or 1 gallon are sufficient. A balance for weighing is also useful. Spoons, bottles, etc. vary considerably in capacity and it is not advisable to depend on them for measuring quantities.

Vessels containing the stock or concentrated spray materials should always be thoroughly shaken before diluting with water for spraying; it is not advisable to allow such diluted mixtures to stand for any length of time.

To save time and labour it is often convenient to combine two or more fungicides and insecticides and thus obtain a dual purpose spray mixture. Care should always be taken to see that combinations are compatible and that the correct proportions of each are maintained. It is safest to follow carefully the directions supplied with each spray material.

Lastly, it is essential *always* to strain spray mixtures before use. This will prevent nozzle blockage.

2. APPLICATION OF SPRAY

Spray solutions should be applied with the correct type of nozzle as indicated earlier. Spraying should as far as possible be done in the early morning or late afternoon as the spray is liable to scorch foliage in strong sunshine. Foliage must be sprayed on *both* surfaces to ensure success. An angle-bend spray rod is essential for this. The spray material should cover adequately every part of the plant, just sufficient being applied for the purpose without waste. There should be a minimum drip off the leaves after spraying.

With most plants, partly owing to the presence of hairs and oil on their surface, the spray fluid instead of spreading evenly forms into drops and often falls off. This difficulty is overcome by adding some substance to the spray mixture to make it spread evenly and adhere to the plant. Casein compounds, resin, flour paste, and soap, are some of the agents used for this purpose.

In actual practice a perfect film of spray material over the entire surface of the plant is probably never obtained, but this is the ideal to be aimed at.

Plants in full bloom must not be sprayed—in such cases adjust the spraying programme so that the plants receive an application immediately before the flowers open and soon after the fruits begin to form. Spraying should not be done when the foliage is drenched after rain or heavy dew —the leaves should be allowed to dry before spraying is commenced.

Spraying should be repeated to replace the material as it gets washed off by rain or loses its efficacy and to cover each burst of young foliage. Time and frequency of spraying depend on the individual pest or disease. Generally speaking it is advisable to spray at short intervals (once in 7-10 days) during periods of rapid growth.

It is not sufficient to spray only diseased plants. *All* plants must be sprayed otherwise unsprayed ones may prove fertile lodgings for infection.

System and method in spraying are very necessary. Working up rows of plants and always starting with each tree at approximately the same position will save overlapping of applications which in total may involve much waste of time, labour and material.

CONCLUSION

It is not justifiable to abandon spraying because immediate benefits are not forthcoming. Repeated applications may be necessary to obtain the desired results. It is suggested that, in order to avoid disappointment, expert advice be sought before spraying is undertaken.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 30 APRIL, 1935

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1933	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	43	...	43	...	...	...
	Anthrax	...	...	...	...	..	...
	Rabies (Dogs)	5	3	...	...	...	5
	Piroplasmosis	...	...		...	...	...
Colombo Municipality	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	2	...	2	...	...	...
	Anthrax (Goats)	1	1	...	1	...	...
	Rabies (Dogs)	6	3	...	...	...	6
	Haemorrhagic Septicaemia	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	
Cattle Quarantine Station	Rinderpest	..	...	...	...	..	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax (Sheep & Goats)	57	10	...	57	...	...
Central	Rinderpest, Foot-and-mouth disease, Anthrax, Bovine Tuberculosis, Rabies (Dogs)	FREE					
Southern	Rinderpest, Foot-and-mouth disease, Anthrax, Rabies (Dogs)	FREE					
Northern	Rinderpest, Foot-and-mouth disease, Anthrax, Black Quarter, Rabies (Dogs)	FREE					
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	40	...	40	...	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	76	12	60	4	12	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	9	3	...	1	...	8
	Piroplasmosis	...	...	...	...	...	...
North-Central	Rinderpest, Foot-and-mouth disease, Anthrax	FREE					
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	85	...	84	1	..	...
	Anthrax	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	..	..
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	...	...	..	...	...	...
	Haemorrhagic Septicaemia	6	1	2	4	...	...
	Rabies (Dogs)	3	1	...	...	...	3

G. V. S. O.
Peradeniya, 15th May, 1935.

M. CRAWFORD.
Government Veterinary Surgeon.

METEOROLOGICAL REPORT,

APRIL, 1935

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo -	88·0	+ 0·4	76·0	+ 0·3	74	91	6·6	3·69	14	– 5·19
Puttalam -	88·6	– 0·5	76·2	+ 0·4	72	88	4·1	5·91	10	+ 1·02
Mannar -	89·9	– 1·4	78·6	+ 0·9	74	86	4·8	4·51	8	+ 1·38
Jaffna -	89·4	+ 0·1	81·0	+ 1·3	76	82	3·8	2·29	7	+ 0·80
Trincomalee -	89·4	+ 0·6	78·0	+ 0·7	71	84	4·8	1·31	5	– 0·68
Batticaloa -	87·8	0	76·7	+ 0·5	72	91	6·0	2·90	5	+ 1·15
Hambantota -	87·4	0	76·1	+ 0·2	76	91	4·4	3·28	8	– 0·03
Galle -	86·2	0	76·8	+ 0·4	76	88	5·7	3·25	13	– 5·53
Ratnapura -	91·9	+ 1·0	73·2	– 0·5	76	98	5·6	15·26	19	+ 4·02
A'pura -	91·8	+ 0·6	74·2	– 0·5	69	95	6·2	3·68	11	– 2·18
Kurunegala -	91·0	– 0·2	73·4	– 1·1	68	98	5·2	12·29	13	+ 2·84
Kandy -	88·7	+ 1·2	69·8	0	66	92	3·7	2·27	8	– 3·96
Badulla -	84·7	+ 0·8	64·9	– 1·2	67	94	4·5	4·96	11	– 1·46
Diyatalawa -	79·0	+ 1·4	58·6	– 1·5	67	88	5·8	2·48	11	– 2·76
Hakgala -	75·6	+ 1·8	52·6	– 2·1	61	91	4·3	3·22	8	– 3·92
N'Eliya -	72·9	+ 1·7	46·3	– 2·9	60	93	5·9	2·64	9	– 2·02

The rainfall of April was nearly everywhere below normal. The stations reporting excess were somewhat irregularly distributed, but were chiefly found on the northern, western, and southern borders of the hill country, and in the north-west of the Island. Excess was slight in most cases. The highest monthly total reported was 22·09 inches, at Kahagalla.

Only three falls of at least 5 inches in a day were reported, the highest being 5·07 inches at Mantota, on the 2nd.

Most of the rain this month fell in the first week or so, as the result of local thunderstorms. The rain then fell off, but increased and became more wide-spread from about the 20th to 23rd, again as the result of local thunderstorms. The gradient, which had been flat and irregular, became moderately south-westerly on the 25th. The resultant westerly or south westerly winds, however, were apparently of no great height, and there was but little rain till the end of the month.

Temperatures were generally a little above normal, except the night temperatures up-country, which were below average. Day humidities at Nuwara Eliya and Hakgala were appreciably below normal, while in the low-country they were generally above normal. Night humidities were generally about the average. Cloud was generally below normal, particularly in the hills.

Barometric pressure was above normal in the west, and below in the east. The wind was generally above normal, while its direction was variable.

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